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THE
DESCRIPTION and USE
OF A
Portable Instrument,

Vulgarly known by the Name of

GUNTER's Quadrant.

By which is perform'd most Propositions
in *Astronomy*; as, the Altitude, Azimuth, Right
Ascension and Declination of the Sun, &c. also
his Rising and Setting, and Amplitude, together
with the Hour of the Day or Night and other
Conclusions exemplify'd at large.

To which is added,

The Use of NEPIER's Bones in *Mul-
tiplication, Division, and Extraction of Roots*; also
the *Nocturnal*, the *Ring-Dial*, and GUNTER's
Line, in many necessary and delightful Conclu-
sions, fitted to the Understanding of all Capacities.

By WILLIAM LEYBOURN.

The Third Edition, with the Addition
of the Use of GUNTER's Quadrant in taking
the Declination of a Plain by the Help of a
Horizontal Dial; also, the Use of a two Foot Rule
in the Mensuration of Timber, &c.

By CHARLES LEADBETTER.

L O N D O N :

Printed for J. WILCOX, in *Little-Britain*, 1731.

THE

DESCRIPTION AND USE

OF A

PORTABLE APPARATUS

FOR THE PURPOSE OF

INVESTIGATING THE NATURE AND EXTENT OF THE DAMAGE DONE BY THE INFLUENCE OF THE SUN'S RAYS ON THE COLOURS OF PAINTS AND WALLS, &c.

BY

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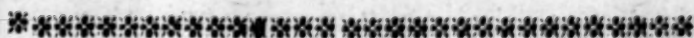
THE

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The USE of a
Portable Instrument
Known by the Name of
G U N T E R ' s Quadrant.



S E C T. I.

Of the Description thereof.

I.  HERE needs no large Description of this Instrument ; for all Persons that are capable of the Use thereof know, 'tis but the fourth Part of a Circle, and divided in the Limb thereof into 90 Degrees, by equal Divisions, and number'd 10, 20, 30, 40, &c. unto 90 ; each Degree being subdivided into 4 Parts, above the Limb. There is inserted the twelve Months of the Year, and distinguished by capital Letters, viz. J. or January,
A 2 F. for

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F. for *February*, *M.* for *March*, &c. and each Month is subdivided into 5 Days, more or less, according as the Largeness of the Quadrant will bear; and then above the Days of the Month you have, in the Body of the Quadrant, the Hours and Azimuth Lines, together with Part of the Ecliptick and Horizon; also a Quadrant, &c. as will be much more obvious and intelligible to the Reader, by Inspection of the Figure thereof hereunto annexed, then by many Words.

2. And, to make the Quadrant compleat, there must be added a Couple of brass Sights with small Holes therein, fixed to one of the Semidiameters of the Quadrant; also a Thread or Silk fasten'd to the Center, with a Bead and Plumet as is usual: And the making hereof is well known to the Workman, and shew'd at large by Mr. *Gunter*. What else is necessary shall be explain'd in its Use.

SECT.

S E C T. II.

Of the Circle of Months.

THis Circle of Months is figured with the Letters *J. F. M. A. M.* &c. signifying the Months *January, February, March, April, May, &c.* each Month being divided unequally, according to the Number of the Days that are contain'd therein, as before is intimated.

1. *And now to find any Day of the Month throughout the Year:* First, search out the Month, and, from the Beginning thereof, account the small Divisions from one Month to another, each of them for five Days, (unless your Quadrant be large, and the Month divided into every Day) and by this Means you easily find the Place (or Division) of the Day of the Month desired, which will be much easier by Practice, than can be express'd by Words: And here note, that every 10th Day is distinguish'd by a longer Line then the rest; thus, if I lay the Thread, (being fixed in the Center) to the ~~10th~~ Day of *January*,
21 A 3 'twill

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'twill cut in about 21 Degrees in the Limb of the Quadrant: Now in *June* and *December*, when the Sun has his greatest North and South Declination, the Divisions here run close, and so the Day of the Month cannot be so exactly found, but guess'd at, and near enough for most Uses; but in all the other Months of the Year, there needs not the least Scruple in this Particular.

2. *Having the Day of the Month, to find out the Sun's meridian Altitude, or how high he will be at Noon?*

Let the Thread be laid upon the Division call'd (or representing) the Day of the Month, and then that very Degree, which the Thread cuts in the Limb of the Quadrant, is the Sun's meridian Altitude required; so the Thread, laid to the ~~15th~~ ^{25th} Day of *May*, will cut 59 gr. 30 m. in the Quadrant's Limb, which is the Sun's Height that Day at Noon; and if it be laid upon the ~~18th~~ ^{28th} Day, the meridian Altitude will be found 41 gr. 39 m.

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call'd GUNTER's Quadrant. 7

3. *The meridian Altitude being known, to find the Day of the Month, which is the converse of the former.*

The Thread, being laid upon the meridian Altitude, doth also fall upon the Day of the Month: So that if you have any one of them, you have both. So, if the Altitude at Noon be 59 gr. 30 min. (as before) and the Thread being set thereunto, it falls upon the ²⁶15th of *May*, and the 9th of *July*, and which of these two is the true Day, may be distinguish'd by the Quarter of the Year, or another Day's Observation: For, if the Altitude prove greater, the Thread will fall on the 16th Day of *May*, and 8th Day of *July*; or, if it prove lesser, the Thread will fall on the 14th Day of *May*, and the 10th of *July*; and thus the Doubt is fully determin'd, and by this we discover also what Days of the Year are of equal Length, which must needs follow by Consequence, if the meridian Altitudes be equal; and so the ^{15th}4th of *September* and ^{15th}18th of *March* have the same meridian Altitude, and the same Length, which is to be understood in

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in the rest of the Months, as they stand opposite in their proper Circles.

4. And here 'tis to be observ'd, that this Quadrant is accommodated but to one Latitude, and therefore (in this Case) serves but for one Place, and such which lye parallel thereunto, *viz.* East or West from thence, (as, suppose from the metropolitan City of *London*) those that lye 60 or 70 Miles North from this Parallel, the Sun will be a Degree lower, than appears by the Quadrant at Noon; and the contrary, one Degree higher from the meridian Altitude, to such as live 60 or 70 Miles South from *London*, or such Places that lye parrallel to it; this is to be understood if you be regulated by the Day of the Month upon the Quadrant.

5. But if you observe the Sun's Altitude just at Noon (or a little before, and a little after Noon) by holding the Quadrant in both your Hands, turning your left Hand towards the Sun, so that the Beams thereof may pass through the Holes of the Sights, then, the Plummet hanging at Liberty, the Degrees cut in the Limb by the Thread, is the
Alti-

call'd GUNTER's *Quadrant.* 9

Altitude desired in any Place; and the same may be done by the Moon and Stars, if you look through the Sights at the Moon or Stars, and observe then what Degrees are cut by the Thread in the Limb: So upon the ²⁴14th Day of *April*, just at Noon, the Sun-Beams passing through both the Sights, the Thread will fall upon 51 gr. 35 min. the true meridian Altitude of the Sun in the Latitude of *London*, for which Meridian most of the Quadrants are made.

S E C T. III.

Of the Hour-Lines on the Quadrant.

1. **O**bserve that the Arch, drawn upon the Center of the Quadrant to the Beginning of the Sun's Declination, doth represent the Equator, or equinoctial Circle (and is usually made a Radius or Tangent) of 45 Degrees; but that Arch which is drawn by 23 gr. 30 min. of Declination, and is just above the Circle of Months and Days, represent the Tropicks of *Capricorn* and *Cancer*

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Cancer, or the Sun's greatest Declination both North and South; and those Arch-Lines, which are described upon the Quadrant between the Equator and the Tropicks, being undivided and number'd at the Equator by 6, 7, 8, 9, 10, 11, 12, and at the Tropicks by 1, 2, 3, 4, 5, 6, 7, 8, those very Lines or Arches are the Hour-Circles.

2. That which is drawn from 12 in the Equator to the Middle of *June*, represents the Hour of 12 in the Summer; and those which are drawn with it towards the right Hand, are the Hours of the Day in Summer, and also of the Night in Winter: But that Arch which is drawn from 12 in the Equator to the Middle of *December*, represents the Hour of 12 in the Winter; and those Arches with it to the left Hand, the rest of the Hours of the Day in Winter, and Night in Summer; and of both these, that which is drawn from 11 to 1, serves for 11 in the Forenoon and 1 in the Afternoon; that which is drawn from 10 to 2, serves for 10 in the Forenoon and 2 in the Afternoon: The Reason is, that the same Day the Sun has the same Altitude 2 Hours before Noon, as it has 2 Hours af-

ter

call'd GUNTER's Quadrant. II

ter Noon; and the same Reason is to be understood in all the rest, which is plain and easily understood, as by the following Propositions will clearly appear.

3. *The Day of the Month, or meridian Altitude of the Sun, being given, to find the Place of the Sun in the Ecliptick.*

Let the Thread be laid to the Day of the Month, or to the Sun's Height at Noon, (for the one gives the other) observe then where it crosses the Hour of 12, and set the Bead to that Intersection; then move the Thread till the Bead fall on the Ecliptick Circle, (which is known by the Characters of the 12 Signs) and it will fall upon the Sun's Place; and so if it were the ~~15~~²⁵th of May, or meridian Altitude 59 gr. 30 min. lay the Thread as aforesaid, and put the Bead to the Intersection of the Hour of 12, and then move the Thread till the Bead fall on the Ecliptick, and it will there touch upon the 4th Degree of Gemini, and the same of Sagittary; also the 26th of Cancer and the 26th of Capricorn; and which of these is the Place of the Sun, may appear

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appear by the Quarter of the Year, or
another Day's Observation.

4. *To rectify the Bead for the Hour of the
Day, &c.*

Knowing the Day of the Month,
place the Thread thereon, and then, slip-
ping the Bead to the Meridian or Hour
of 12, for the Season of the Year,
you are fitted to find the Hour by the
Sun; but for the Stars, only lay the Bead
upon the Star proposed. And thus, the
Bead being rectify'd, if you do but ob-
serve the Altitude of the Sun, the Bead
will fall on the Hour-Line desired or
sought, if you bring the Thread to the
Altitude: So on the 10th of April, having
rectify'd the Bead for the Time, you may
find the Altitude 36 gr. at the same time
the Bead falls upon the Hour-Line of 3
and 9; and then I may conclude, 'tis 9
in the Forenoon, or 3 in the Afternoon;
and so upon the 9th of April, the Bead
being rectify'd, and the Altitude ob-
serv'd 30 gr. the Bead will fall between 8
and 9 in the Equator, and between 3 and
4 in the Tropicks; so that 'tis half an
Hour past 8 in the Morning, or half an
Hour

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Hour past 3 in the Afternoon, and here observe, if the Sun ascends, it is be Forenoon; but if the Sun descends or falls in Altitude, 'tis Afternoon, as Reason itself will direct: So again, upon the aforesaid ~~10th~~ ²⁴ of *April*, if the Sun's Altitude be 40 gr. you will find the Bead at the same time fall half way between the Hour-Lines 9 and 10, or 2 and 3; wherefore it must either be half an Hour past 9 in the Morning, or half an Hour past 2 in the Afternoon, which is most easily distinguish'd. And after the same Method, if upon the ~~1st~~ of *November* I observe as aforesaid, and find the Bead to fall half way between 8 and 9, and 3 and 4 in the Winter-Hour-Circles; hence I conclude, 'tis half an Hour past 8 in the Forenoon, or half an Hour past 3 in the Afternoon, & sic de cæteris.

5. *The Place of the Sun in the Ecliptick being known, to find the Day of the Month.*

Lay the Thread and Bead on the Place of the Sun in the Ecliptick, and then move the Thread and Bead to the Hour of 12, and so, if the Place of the Sun be 4 gr. of *Gemini*, the Bead being laid to this Degree, and then moved to the

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Hour

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Hour of 12 in Summer, the Thread
26 will fall on the ²⁶5th Day of May, or
19 the 8th of July; or, if it be moved to
17 the Hour of 12 in Winter, the Thread
25 will fall on the 6th of January and the
14th of November, and which of these is
the Day of the Month requir'd, the
Quarter of the Year will determine.

By this and the third Proposition,
there is two Ways shew'd to rectify the
Bead by the Place of the Sun, and by
the Day of the Month; but the best Way
is that by the Place of the Sun, for
in the other some small Difference
may arise by the Leap-year. There
is also a third Way by a Table of the
Sun's Declination for each Day of the
Year, (which Seamen are seldom with-
out) and if so, the Bead may be set there-
unto in the Line of Declination.

6. *To know how high the Sun will be,
at any Hour of the Day given, through-
out the Year.*

The Bead being rectify'd for the
Time, by any of the Ways aforesaid,
bring it to the Hour given from the
Hour of 12 towards the Line of Declination

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nation, and the Degrees, cut by the Thread in the Quadrant or Limb thereof, will shew the Altitude of the Sun at that Time; so upon the 30th of *March*, at 8 in the Morning and 4 in the Afternoon, the Sun will be found to be 24 gr. 30 min. high: Again, on the 10th of *April*, the Sun being in the Beginning of *Taurus*, the Bead being rectify'd, you shall find the Altitude at Noon at *London* 50 gr. 15 min. but at 11 in the Morning 48 gr. 12 min. at 10 of the Clock but 43 gr. 12 min. at 9 only 36 gr. at 8 of the Clock 27 gr. 30 min. at 7 but 18 gr. 18 min. at 6 in the Morning but 9 gr. and at 5 a Clock it touches the Line of Declination, and has no Altitude at all; whence we may conclude, the Sun did rise much about that Hour. And then, if you move the Thread again from the Line of Declination towards the Hour of 12, you shall find the Sun 8 gr. 33 min. below the Horizon at 4 in the Morning, and near 16 gr. at 3, and 21 gr. 51 min. at 2, and 25 gr. 40 min. at 1, and 27 gr. at Midnight. For the Bead being rectify'd as aforesaid, and brought to the Hour of the Night (which, as before was intimated, are the Winter-Hours

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in the Summer, and the Summer-Hours in Winter) then the Thread in the Limb cuts the Degree of the Sun's Depression for any Hour of the Night; and thus 'twill be found, that at a 11 of the Clock at Night, the ~~30th~~ of *March*, the Sun will be found at least 28 gr. 30 min. below the Horizon.

April 10th

7. *The Hour of the Night given, to find the Sun's Depression.*

And here let it be observed, that the Sun is always as much below the Horizon at any Hour of the Night, as his opposite Point is above the Horizon at the like Hour of the Day, and therefore (to make this more plain) the Bead being set, if the Question be put for any Hour of the Night in Summer, then move it to the like Hour of the Day in the Winter-Hours: But if of any Hour of the Night in Winter, then move the Bead to the like Hour of the Day in Summer, and so the Degrees, cut by the Thread in the Limb of the Quadrant, shall shew how much the Sun is below the Horizon at that Time: And so suppose it the ~~10th~~ of *April*, at 4 of the Clock in the

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the Morning, the Bead being set to his Place, according to the Time in the Summer-Hours, and brought to 4 of the Clock in the Afternoon in the Winter-Hours, you will find the Thread to cut 8 gr. and about 30 min. in the Limb of the Quadrant, which is the true Depression of the Sun at that Time.

8. *The Depression of the Sun supposed, to give the Hour of the Night with us, or the Hour of the Day to our Antipodes.*

In regard the Sun is as much above the Horizon at all Hours of the Day, as his opposite Point is below the Horizon at the like Hours of the Night; therefore, first set the Bead according to the Time, and then bring the Thread to the Degree of the Sun's Depression below the Horizon, so shall the Bead fall on the contrary Hour-Lines, and thereby shew the Hour of the Night in respect of us, which is the like Hour of the Day to our Antipodes: So the ^{24th} 25th of April, the Sun being then in the Beginning of *Taurus*, and, by Supposition, 8 gr. 30 min. below the Horizon in the East, it is required to be known, What Time of

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the Night it is? First set the Bead
according to the Day in the Summer-
Hours, then bring the Thread to 8 gr.
30 min. in the Limb of the Quadrant,
so shall the Bead fall among the Win-
ter-Hours on the Line of 4 of the Clock
in the Afternoon; wherefore to our An-
tipodes 'tis 4 of the Clock in the After-
noon, and to us 4 in the Morning.

9. *Having the Time of the Year, or the
Place of the Sun being known, how by
this Quadrant to find the Beginning of
Day-break, and End of Twilight.*

There is very little Difference be-
tween this Proposition and the former;
for the Day is said to break when the
Sun comes to be but 18 gr. below the
Horizon in the East, and Twilight to
end when the Sun is 18 gr. below the
Horizon in the West; wherefore let the
Bead be set for the Time, and then bring
the Thread to 18 gr. in the Quadrant,
so shall the Bead, falling upon the con-
trary Hour-Lines, there shew the Hour
of Twilight, as before in the Operation
of the last Proposition, and so 'twill be
found a little more then a Quarter after

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3 in the Morning, for Day-break upon the ~~10th~~^{2d} of *April*; after the same Manner upon the 30th of *March*, Day-break *April 10* will be found to be at 3 of the Clock in the Morning; and if so, we may easily judge when 'twill be dark at Night, which is said to be as much after 6, as this is before 6, and then we may conclude 'twill be dark at 9 of the Clock at Night, it being then past Twilight.

S E C T. IV.

Of the Azimuth-Lines.

1. **O**BSERVE that those arching Lines, which are drawn between the Equator and the Tropicks, on that Side of the Quadrant towards the right Hand, or nearest to the Sights, and are number'd with 10, 20, 30, 40, &c. in the Equinoctial, then downwards from the Equator to the Tropicks with 110, 120, 130, &c. the uttermost towards the left Hand, representeth the Meridian; that which is number'd with 10, the tenth Azimuth from the Meridian;

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dian ; and that which is number'd with
20, the twentieth ; and so of the rest.
Those Lines, which are drawn from the
Equator to the left Hand, do shew the
Azimuth in the Summer ; and those o-
ther to the right Hand, do shew the
same in the Winter. The Uses of them
follow.

2: *The Azimuth, the Sun is upon being
known, to find the Altitude of the Sun a-
bove the Horizon.*

First let the Bead be set for the Time,
as before is shewed, then move the
Thread until the Bead fall on the Azi-
muth ; so the Degrees, which the Thread
cutteth in the Quadrant, shall shew the
Altitude of the Sun at that Time : Where
you are to observe, that, in regard the
Azimuths are drawn on the right Side
of the Quadrant, you are also to begin,
to number the Degrees of the Sun's Al-
titude, from the right Hand towards the
left, contrary to the Directions of some
former Propositions. Examples will
clear this Point ; Suppose the Time gi-
ven were the ¹³second of August, when the
Sun hath but 14 gr. 49 m. of North De-
clination,

the degree from 90 Backwards

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Declination, set the Bead for the Time, and the Sun's Meridian Altitude, or Height at Noon, will be found 53 gr. 17 min. But when he is 10 gr. from the South, 53 gr. 10 min. when 20 gr. then about 52 gr. 8. min. when 30 gr. then 50 gr. 20 min. when 40 gr. then 47 gr. 28 min. when 50 gr. then 44 gr. 12 min. when 60 gr. then 39 gr. 35 min. when 70 gr. then 33 gr. 50 min. when 80 gr. then 27 gr. when the Sun is in the East or West 90 gr. from the Meridian, then is the Altitude near 19 gr. 20 min. when 110 gr. then 3 gr. 20 min. and before he cometh to the Azimuth 120 gr. he has no Altitude, for the Sun having 14 gr. 49 min. of North Declination will rise and set at 114 gr. 34 min. Azimuth from the Meridian.

3. *The Altitude of the Sun being given, to find on what Azimuth, or Point of the Compass, he bears from us.*

Set the Bead in his proper Place for the Day proposed (as before directed) and then, observing the Sun's Altitude, lay the Thread to the Complement of that Altitude, (which is but accounting
so

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so many Degrees from 90 gr.) on the Quadrant, so shall the Bead fall upon the true Azimuth required. Example: Suppose upon the ~~second~~^{2nd} of August (having rectify'd the Bead) you observe and find the Sun's Altitude to be 19 gr. 20 min. then remove the Thread to the Complement thereof, viz. 70 gr. 40 min. or, which is all one, upon 19 gr. 20 min. accounted from 90 gr. from the right Hand to the left, and the Bead will fall upon 90 gr. from the Meridian; and therefore the Point the Sun is upon bears from us, either full East or full West; and which of these it is, may immediately be discovered by a second Observation; for if the Sun, increase in Altitude, 'tis Forenoon, and the Azimuth East; if the Sun decrease in Altitude, 'tis Afternoon, and then the Azimuth is West; which is as easily discovered, by the Hour of the Day. And so again, if I find the Sun's Altitude to be 25 gr. if I lay the Thread to 25 gr. accounted backward from 90 gr. the Bead will fall upon very near 80 gr. from the South, and that is the Point of the Compass the Sun is upon Eastward, if in the Morning; and Westward, if in the Afternoon. By these

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These Propositions you may know the Altitude of the Sun every Hour of the Day, though he appears not; and what Part of the Heavens he is in likewise; and, then knowing what Azimuth the Sun beareth from us, you may find not only the Meridian Line, but the Coasting of a Country, the Situation of a Building, and the Variation of the Compass, &c. as for Example: Suppose some Day in the Afternoon, I should find, by the aforesaid Direction, that the Sun bears from me 30 gr. from the South towards the West, when, there being 90 gr. in each Quarter of the Compass, the West will appear to be 30 gr. to the right Hand, the East is just opposite to the West, and the Meridian-Line, or North and South, lyes in the midst between them.

To find the 4 Cardinal Points upon an horizontal Plain.

First find the Azimuth of the Sun, and instantly lay your Quadrant upon the Plain, so that the Face thereof may lye uppermost, then hold in your Hand some small String with a Plummet hanging thereunto, and move the Quadrant till the

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the Sun casteth the Shadow of the String through the Degree of the Limb which was found for the Azimuth, and through the Center of the Quadrant; then, holding the Quadrant still, draw Right-Lines by each Side thereof, and protract them, so that they may cross each other, and these Lines shall point out East, West, North, and South.

5. *If two several Sun-Shadows be observed, the one in the Forenoon, and the other in the Afternoon of the same Day, exactly to touch with their Ends, the Circumference of the same Circle describ'd in a Plain, parallel to the Plain of the Horizon, the Line from the Center, equally dividing the Arch of that Circle betwixt the two Shadows, will be the true Meridian in that Place.*

This is a useful Theorem, and may be better understood by Example, viz. Take a Piece of Board or Mettle, and let it be so evenly placed, that it may lye parallel with the Plain of the Horizon; in this Plain describe divers Circles from the same Center, and in that Center raise a Gnomon at Right-Angles. This

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This Platform being thus order'd, let the Shadow of the Gnomon, or Wire, be observ'd some time before Noon, till such time it do exactly touch the Circumference of one of these Circles. Again, in the Afternoon, let the Shadow be observed till the End of this Perpendicular touch the Circumference of the same Circle, which will exactly happen so many Hours after Noon, as the other before Noon; then you are diligently to observe these two Points in the Arch of the said Circle, and divide that Arch into two equal Parts by a Line from the Center; this very Line is a true meridian Line, upon which when the Shadow falls, you may be sure 'tis just 12 of the Clock, or just high Noon.

6. To find the Declination of a Wall for the making of a declining Dial.

Apply one Edge of the Quadrant to the Wall, and at the Limb hold up a Thread and Plummert, so that the Shadow thereof may pass through the Center, then, marking what Degree of the Limb the Shadow of the String so held

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shall

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shall touch, presently find the Degree in the Limb of the Sun's Azimuth at that time; then, if you have done right, the Degrees between the Degree of the Azimuth of the Sun, and the Degree of the Shadow of the String so mark'd, shall be the Degree of the Declination of the Wall from the true Meridian; which, whether it be Eastward or Westward, may be known by comparing it with the Sun. And note, this Proposition may be the better perform'd, the farther the Sun is from the Meridian.

7. *To find how much a Plain or Wall declines from the Zenith.*

Apply the Edge of the Quadrant to the Plain or Wall, so that the Center may be downwards, and the Limb upwards; then hold a String and Plummets, so that the Thread or String may touch the Center and the Limb, and number the Degrees between the Plain and the String, which will shew the Quantity in Degrees of the Plain's Reclination

8. *To*

8. *To find the Elevation of the Pole in any Place.*

First take the meridian Altitude of the Sun by Observation, (or otherwise) and also the Sun's Declination (as shall be shew'd) which if it be Northwards, subtract, if Southwards, add to the Sun's meridian Altitude, and you have the Complement of the Pole's Elevation, or the equinoctial Height; which subtracted out of 90 gr. leaves the Latitude of the Place desir'd, which is so plain, it needs no Example.

S E C T. V.

Of the Ecliptick Circle or Arch.

1. **T**HE Ecliptick, is easily distinguished from the other Circles, and is represented by the Arch, to which is annexed the Characters of the 12 Signs, and is drawn from the Hour-Line of 6 in the Equator, to the other side of the Quadrant, ending in the Tropicks of
C 2 Cancer

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Cancer and *Capricorn*, each Sign being divided unequally into 30 gr. which is to be reckon'd both ways from the Characters of the 12 Signs, *Aries*, *Taurus*, *Gemini*, *Cancer*, *Leo*, *Virgo*, *Libra*, *Scorpio*, *Sagittary*, *Capricorn*, *Aquary*, *Pisces*, which Signs do also answer to the 12 Months; and the Thread being laid upon the Day of the Month, and the Bead rectify'd, or brought to the proper Meridian, or 12, as before has been exemplify'd, according to the Season of the Year, viz. to the Summer-12 in Summer, and the Winter 12 in Winter, &c. Then bring the Bead to the Ecliptick (so rectify'd) and it will fall upon the Sun's Place therein for that Day, regard being had to the Time of the Year: So upon the 18th of *March*, the Sun's Place, by the falling of the Bead, will be about 8 gr. of *Aries*, and upon the 17th of *October* in 4 gr. 30 m. of *Scorpio*.

2. In finding the Place of the Sun in the Ecliptick, 'tis necessary to know which Way the Sun declines from the Equator; for if he declines North, the Character belonging to his Place is above the Ecliptick, if South, beneath it. Now, for as much as the Bead will fall

call'd GUNTER'S Quadrant. 29

fall between two Characters, you may know which it is, by a second Day's Observation; as for Example: Let the 20th of *August* be suppos'd, the Thread being plac'd upon the Day, bring the Bead to the Summer-Meridian, which will shew that the Sun is then in its Northern Declination (because the Bead very plainly shews the same) and the Thread being moved falls either on the 7th gr. of *Virgo*, or at 22 gr. 3 m. of *Aries*, which the Time of the Year will plainly distinguish; for *Aries, Taurus, Gemini, Cancer, Leo, Virgo*, are the Northern or Summer-Signs, and *Libra, Scorpio, Sagittary, Capricorn, Aquary and Pisces*, are the Southern or Winter-Signs: And this Proposition will be found exceeding easy by a little Practice.

3. If the Thread be laid upon the Degree of the Sun's Place in the Ecliptick exactly, it will cut in the Limb of the Quadrant, the Right Ascension of the Sun; so the Sun's Place being 4 gr. of *Gemini*, the Thread laid upon this Degree, will cut 62 gr. in the Limb for the Sun's Right Ascension requir'd: But if the Sun has pass'd about 90 gr. from *Aries*, or more than 3 Signs, then there must be

30 *The Use of a portable Instrument,*

be more than 90 gr. allow'd to the Right Ascension: Thus, if the Degrees of the Sun's Place be between *Aries* and *Cancer*, then his Right Ascension is the very Degrees cut by the Thread in the Limb; but if the Sun's Place be between *Cancer* and *Libra*, then to the first Quadrant you must add those Degrees cut by the Thread in the Limb, counting backwards from the Sights-side; if between *Libra* and *Capricorn*, then to 180 gr. add what the Thread cuts; if between *Capricorn* and *Aries*, then to 270 gr. add the Degrees cut by the Thread in the Limb, counting backwards again, and you have the Sun's true Right Ascension desired: So if the Sun be in 26 gr. of *Cancer*, though the Thread falls upon 62 gr. as before, yet the Complement thereunto must be added, viz. 28 gr. and so the Right Ascension will be 118 gr. So upon the 18th of *March*, the Right Ascension is but 7 gr. but upon the 5th of *August* 145 gr. upon the 10th of *October* 206 gr. and upon the 9th of *March* 360 gr. and thus the Business of Right Ascension is made as plain as possible may be to the meanest Capacity. *Ufus promptus facit.*

And

call'd GUNTER's Quadrant. 31

And thus, having the Right Ascension given, you may by the converse Work find the Sun's Place; for lay but the Thread to the Sun's true Right Ascension in the Limb, and it will cross the Sun's Place in the Ecliptick desired.

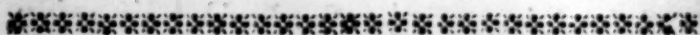
S E C T. VI.

Of the Line of the Sun's Declination.

THE Line of Declination is drawn from the Center to the Beginning of the Quadrant, and divided from the Beginning of *Aries* downwards to 23 gr. 29 min.

Its Use is thus, rectify the Bead as before shewed, and bring it to the Line of Declination, and you have the Sun's Declination for that Day: So if the Sun's Place given be the 4th gr. of *Gemini*, the Bead first set to this Place, and then moved to the Line of Declination, will there shew it to be 20 gr. 59 min. Declination, Northerly from the Equinoctial; and so, if you have only the Day of the Month given, you may presently

32 *The Use of a portable Instrument,*
 sently find both the Sun's Place, and Declination also for that Day : Thus upon the 17th of *October* the Sun has 13 gr. of Declination South. And note, that if the Bead fall upon the Winter-12, the Declination is South ; but if upon the Summer-12, 'tis North ; and, having the Declination only given, you may thereby find the Sun's Place, and Day of the Month.



S E C T. VII.

Of the Horizon.

1. **T**HE Horizon is represented upon the Quadrant by the Arch drawn from the Beginning of Declination towards the End of *February*, divided unequally, and number'd by 10, 20, 30, 40, &c.

2. *Having the Place of the Sun, or Day of the Month, to find the Amplitude of the Sun's Rising and Setting.*

Let

call'd GUNTER's Quadrant. 33

Let the Bead, rectify'd to the Time given, be brought to the Horizon, and there it shall shew the Amplitude required: So if the Day of the Month given be the 15th Day of *May*, and the Sun the 4th gr. of *Gemini*, the Bead, rectify'd and brought to the Horizon, shall there fall upon 35 gr. 8 min. and this is the Amplitude of the Sun's Rising from the East, and Setting from the West; which Amplitude is always North if the Sun be in northern Signs, but when he is in southern Signs, then 'tis always Southward; that is, from the 10th of *March* to the 11th or 12th of *September* North, but all the other half Year, the Amplitude of the Sun is Southerly; and so upon the 9th of *April*, the Amplitude will be found just 18 gr. Northerly. Understand the same Method in other Operations.

3. *The Day of the Month, or the Sun's Place given, to find the Sun's Ascensional Difference.*

Let the Bead, rectify'd for the Time, be brought to the Horizon, so shall the

34 *The Use of a portable Instrument,*

the Degrees, cut by the Thread in the Quadrant, shew the Sun's Ascensional Difference : So upon the ²¹10th of *May*, the Sun being in the last Degree of *Taurus*, or Beginning of *Gemini*, let the Bead be rectify'd and brought to the Horizon, and then the Thread, in the Limb of the Quadrant, shall shew the Ascensional Difference to be 27 gr. 30 min. And so upon the ²⁶15th of *May*, the Sun being about 4 or 5 gr. of *Gemini*, the Ascensional Difference will be found near 29 gr. or rather 28 gr. 50 min. So upon the ²⁰9th of *April* the Ascensional Difference will be found 15 gr. Now, having this, you may thereby find the Time of the Rising and Setting of the Sun, (which by some of the former Propositions may be guess'd at) but more accurately thus ; if the Ascensional Difference be converted into Time, by allowing one Hour for every 15 gr. and 4 min. of an Hour for each Degree, and this will shew how long the Sun riseth before six in the Summer (that is, from the ²¹10th of *March* to the ²²11th or 12th of *September*) and after six of the Clock in Winter : So if the Day propos'd be the 15th of *May*, and the Place

26

of

call'd GUNTER'S Quadrant. 35

of the Sun, and Ascensional Difference as before, *viz.* 28 gr. 50 min. this converted into Time, make 1 h. and about 55 min. and so long did the Sun rise before six, *viz.* at 4 h. and 5 min. in the Morning, and consequently sets so much after six; and in the Winter, so much as the Sun rises after six, so much it sets before six. Hence the Length of the Day and Night is most easily obtain'd; for having the semidiurnal Arch, or Time from Sun-Rising to Noon, 'tis but doubling those Hours and Minutes, and you have the Length of the Day; so 7 h. 55 min. doubled, is 15 h. 50 min. for the Length of the Day, May the 15th, which subtracted out of 24 h. remains 8 h. 10 min. for the Length of the Night.

SECT:

S E C T. VIII.

Of the Five Stars.

THE Stars that were thought convenient (by the Author) to put upon the Quadrant, are first, *Ala Pegasi* a Star in the Extremity of the Wing of the *Pegasus*, in regard it wants but 1 min. of Time of the Beginning of *Aries*; and, because 'tis not always to be seen, four more were elected for each Quarter of the Ecliptick; an *Oculus Tauri*, or the *Bull's-Eye*, whose Right Ascension in time is 4 h. 20 m. then of *Cor Leonis*, the Lyon's Heart, whose Right Ascension is 9 h. 54 min. the next of *Arcturus*, whose Right Ascension is 14 h. 3 min. and the last of *Aquila*, or the Vulture's Heart, whose Right Ascension is 19 h. 37 min. These five Stars have all of them northern Declination, and of all others some of these will be seen (if the Air be clear) every Night in the Year. Their Use follows, viz.

1. The

call'd GUNTER's Quadrant. 37

1. The Altitude of either of these five Stars being known, to find the Hour of the Night. First, put the Bead to the Star which you intend to observe, then take his Altitude, and by that find how many Hours he is distant from Midnight, either before or after; then from the Right Ascension of the Star, subtract the Right Ascension of the Sun converted into Time, and reserve the Difference; for this Difference being added to the observ'd Hour of the Star from the Meridian, or Midnight, shall shew how many Hours the Sun is gone from Noon, which is the Hour of the Night.

2. As for Example, ²⁶May ~~15~~, suppose the Sun be in 4 gr. of *Gemini*, and I set the Bead to *Arcturus*, and observing his Altitude, should find him to be in the West about 52 gr. high, and the Bead to fall on the Hour-Line of 2 Afternoon, the Hour would be 11 h. 50 min. past Noon, or but 10 min. short of Midnight: For 62 gr. the Right Ascension of the Sun converted into Time, makes 4 h. 8 min. which if we take out of 14 h. 3 min. the Right Ascension of *Arcturus*, the Difference will be 9 h. 55 min

D

an

38 *The Use of a portable Instrument,*

and this being added to 2 Hours, the observed Distance of *Arcturus* from the Meridian, shews the Hour of the Night to be 11 h. 55 min. as aforesaid.

3. Again, to make the Business more plain, suppose the 9th of July, and the Sun be then in 27 gr. of *Cancer*, I should set the Bead upon *Oculus Tauri*; and, observing his Altitude, should find him to be in the East, about 12 gr. high, and the Bead to fall on the Hour-Line of 6 before Noon, which is 18 h. past the Meridian, the Hour of the Night would be found somewhat more than 15 min. past 2 in the Morning, which may be proved thus: The Right Ascension of the Sun is 119 gr. which converted into Time (by allowing 15 gr. for an Hour, and 4 min. for a gr.) it makes 7 h. 56 min. this subtracted out of 4 h. 20 m. the Right Ascension of *Oculus Tauri* (adding the Circle, or 360 gr. that Substraction may be made) the Difference will be 20 gr. 24 min. and this being added to 18 h. (which was the observ'd Distance of the Star from the Meridian) shews, that the Sun (abating 24 Hours, or the whole Circle) is 14 h. 24

call'd GUNTER's Quadrant. 39

a. 24 min. past the Meridian, and therefore 24 min. past 2 in the Morning.

4. Now, if you have a Nocturnal upon the Backside of the Quadrant, you need not use this Equation of Right Ascension; for, knowing the Time of the Year, when the Star will be South at Midnight, you may bring that Time to the Hour observed; then will the Day of the Month, wherein you made your Observation, point at the Hour of the Night required.

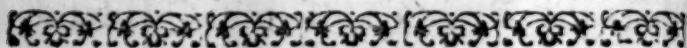
5. As in the first Example, where, on the 15 of *May*, the Bead, set to *Arcturus*, fell upon the Hour-Line of 2 Afternoon; because this Star will be in the South the 14th of *October*, compleat at Midnight, you may place the 14th of *October* at the Hour of 2; so the 15th of *May* will point to 11 h. 55 min. as before, the Hour of the Night desired.

6. And in the second Example, of the 10th of *July*, where the Bead, set to the *Bull's Eye*, fell on the Hour-Line of 6 before Noon; because the *Bull's Eye* will be in the South the 16th of *May*, compleat, at Midnight, you may turn the 16th of *May* to the Hour of 6, and

D 2

thereby

40 *The Use of a portable Instrument,*
thereby you shall find the 9th of July,
to point unto 2 h. 24 min. as before.



S E C T. IX.

Of the Quadrant.

1. **T**HE Quadrant hath two Sides only divided, and the other two Sides, next unto the Center, may be supposed to be divided, each of them into 100 equal Parts; that which is next to the Horizontal Line, contains the Parts of Right Shadow; the other next to the Sights, the Parts of Contrary Shadow. Its Use follows.

2. *Any Point being given, to find whether it be level with the Eye or not*

If you lift up the Center of the Quadrant, so as the Thread with the Plummet may play easily by the Side of it, and look through the Sights to the Place given, and the Thread fall upon the Line A B, drawn by the Side of the Quadrant (call'd the Horizontal Line)

call'd GUNTER'S Quadrant. 41

Line) then is the Place given level with the Eye; but if it fall within the said Line on any of the Divisions, then it is higher; if without, it must needs be lower, than the true Level of the Eye.

3. To find any Height above the Level of the Eye, or a Distance at one Observation.

Look through the Sights to the Place, going nearer or farther from it, till the Thread fall on 100 Parts in the Quadrant, or 45 gr. in the Quadrant; so shall the Height of the Place, above the Level of the Eye, be equal to the Distance 'twixt the Place and the Eye. But if the Thread fall on 50 Parts of Right Shadow, the Height is but half the Distance; if it fall on 25, it is a Quarter of the Distance; if on 75, 'tis three Quarters of the Distance; for as oft as the Thread falls upon the Part of Right Shadow, it holds this Proportion, viz.

As 100 is to the Parts upon which the Thread falls: So is the Distance to the Height required.

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And so on the contrary,

As the Parts cut by the Thread are to 100: So is the Height to the Distance.

4. But when the Thread shall fall upon the Parts of Contrary Shadow, if it fall on 50 Parts, the Height is double the Distance; if on 25, 'tis four Times as much as the Distance: For as often as the Thread falleth on the Parts of Contrary Shadow, the Proportion is,

As the Parts cut by the Thread are to 100: So is the Distance unto the Height.

And the contrary,

As 100 is unto the Parts cut by the Thread: So is the Height unto the Distance.

And what is here said of Height and Distance, the same may be understood of Height and Shadow.

5. *To find a Height or Distance at two Observations.*

Suppose

call'd GUNTER's Quadrant. 43

Suppose the Place, which is to be measured, could not otherwise be approached, and yet it were required to find the Height and Distance; first, I make choice of a Station where the Thread may fall on 100 Parts in the Quadrant, and 45 gr. in the Quadrant; then shall the Distance from the Object be equal to its Altitude. But if I go farther, in a direct Line with the former Distance, and make choice of a second Station, where the Thread may fall on 50 Parts of Right Shadow, then shall the Distance, from the Object to my Station, be double the Height of the Object: Wherefore, if I measure the Difference between the two Stations, it will be equal both to the first Distance, and the Altitude of the Object. But if I cannot make choice of such Stations, then I take such as I may; as suppose one, where the Thread falls upon 50 Parts of Right Shadow, and the second upon 40, and suppose the Altitude of the Object 100, &c. the Proportion holds,

As 50 Parts are unto 100, the Side of the Quadrant: So is 100, the supposed Height, unto 200, the Distance.

And,

44 *The Use of a portable Instrument,*

And,

As 40 Parts, at the second Station, are unto 100: So is 100, the supposed Height, unto 250, the Distance desired.

Wherefore the Difference, between the two last Stations, should seem to be 50; and then, if, in the Measuring of it, I find it to be either more or less, the Proportion holds, as from the supposed Difference to the measured Difference; so from Height to Height, and from Distance to Distance: As if the Difference between the two last Stations, being measured, were found to be 30; then say, by the Rule of Proportion, or the Golden Rule,

As 50, the supposed Difference, is unto 30, the true: So is 100, the supposed Height, unto 60, the true Altitude.

And,

As 200, the supposed Distance, is unto 120, the true: So is 150, at the second Station, unto 250, the Distance required.

6. If

call'd GUNTER's Quadrant. 45

6. If standing upon a known Altitude, and you would thereby know the Distance, work as you did before; only that which was then the Parts of Right Shadow, must now be the Parts of Contrary Shadow; and that which was then the Parts of Contrary Shadow, must now be the Parts of Right Shadow.

S E C T. X.

The Description and Use of the Nocturnal, which is usually put upon the Backside of Gunter's Quadrant.

1. **I**T S an Instrument fitted chiefly to know the Hour of the Night by the Stars: It consists of two Parts, the Fixed and the Moveable. The fixed Part, being the outermost Circle, is divided into 24 Parts, representing the Hours of the Night; of which so many as are necessary are inserted, which are from 4 in the Afternoon till 8 in the Morning: Each Hour is divided into Halves, Quarters, and Half-Quarters, and farther,

46 *The Use of a portable Instrument,*

ther, according as the Instrument will bear. This Part must be fixed on the Back of some other Instrument, or it may be used by itself.

2. The other Part is moveable on its Center; the outward Circle next the Edge is divided into 365 Parts, representing the Days of the Year; and these are divided into Months, which are distinguished by Divisions and Figures, to know every Day, as is usual, and the Name to each Month. Within this moveable Place, there is inserted five Constellations of those Stars that are next the North Pole; and in some a Star of the first Magnitude, called *Hircus*; all which (without incumbring the Nocturnal with more) are sufficient for this Use. There is likewise a Thread to be added, lying on the Diameter from 12 to 12, which serves for a Meridian; to which those that please may have added a Scale of Declinations, and a Circle divided into 360 gr. for finding the Right Ascension, and Declination of these Stars; but that Work may be done with ease many other Ways, and is usually omitted in the Instrument.

2. The

2. The Use of this Instrument is thus: First, learn to know the Stars, which are usually placed upon this Instrument, which is very easy from the bare Inspection of the Nocturnal itself, and they are most easily known in the Heavens: If you turn yourself to the North, and there observe the seven great bright Stars, in the *greater Bear*, called by most People *Charles's Wayne*, those four in a square Form are in the Body of the Bear, the three other are in the Bear's Tail: Having found these, take notice that the two Stars in the Square, farthest from the Tail of the Bear, do in a streight Line point to another Star almost as big as they are (which is in the Tip of the *little Bear's Tail*) and called the Polar Star, or North Star, and very near, tho' not exactly, in the Pole. These being known, the rest will be easily found out, by bare Inspection of the Instrument.

3. The Stars being known, now for the more certain Finding of the Hour of the Night, it will be necessary to find a Meridian, which is a Line, or Arch, conceived to be drawn through or near the North Star, and so right over your Head;

48 *The Use of a portable Instrument,*

Head; and round about by the South, just under your Feet, until it meet in the North Star again; or, to spake more properly, it is a Circle that passeth through the North and South Poles, and the Zenith and Nadir of the Place, and divideth the Firmament into the East and West Hemispheres: And to find this Meridian, I have already shewn in the Use of the Quadrant. One good Way may be, in some Garden, or private Place, where you may clearly see the Stars, both above and below the Pole, to pitch exactly upright, and at some Distance, two Poles of a good length; but this must be done just at Noon, so that the Shadow, made (by the Sun at that Time) of them both, may be in a direct Line, which is a true Meridian. This being premised:

4. If at any Time of the Night you would find the Hour by the Nocturnal, stand by the Southermost of your Poles, (before set up) bring it in a Right Line with the other, so that the Pole by you may hide the other from your Eye; then see what Stars are hid from your Eye by these two Poles, either above or below the Polar or North Star, which
are.

call'd GUNTER's Quadrant. 49

are then upon the Meridian: Then coming to your Nocturnal by the Help of your Thread, bring the moveable Part thereof into the same Position as you find the Stars in the Firmament, setting those upon the Meridian under the Thread, that you find to be hid from your Eye by the two Poles: Then find, in the moveable Part, the Day of the Month of your Observation, and just against it, on the fixed Part, you shall find the Hour of the Night.

5. But as it would be a most certain Way to have a Meridian for a while to exercise, until you are well acquainted with the Operation and Performance; yet you may come very near to the Matter (and near enough for common Use) without a Meridian, thus: When you know the Polar Star, place your Body directly upon the Star, and imagining a Line drawn from the Zenith, or Point directly over your Head, through the said Star, and so directly down to the Earth, observe what Stars, of those that are on your Plate, either over or under the Pole Star, are upon that supposed Line which is your Meridian; then, coming to your Nocturnal,
E place

50 *The Use of a portable Instrument,*

place the moveable Part in the same Posture, and just against the Day of the Month, on the moveable Part, is the Hour of the Night.

6. An Example or two will make all plain.

Suppose, upon the first of *August*, in the Year 1731, finding, by either of the former Ways, that the two Stars of *Charles's Wayne*, that are farthest from the Tail of the Bear (which, as I said before, point directly to the Polar Star) are on the Meridian below the Pole; then, coming to my Nocturnal, I bring those Stars under my Thread below the Pole, and then, looking for the Day of the Month *August* 1st, I find that 'tis almost half an Hour past one a Clock in the Morning. And the same Night finding that Star in the Nose of the great Bear, to be on the Meridian below the Pole, I place this under my String in my Nocturnal, and seek the Day of the Month, and against it I find it to be half an Hour past 10 at Night: And so upon *July* the 1st, finding the Star *Hircus* (a Star of the first Magnitude) to be on the Meridian below the Pole, I bring my moveable Part to its proper

Use of the Ring-Dial. 51

proper Place, (as before directed) and
and it to be half an Hour past nine a
Clock at Night; *et sic de ceteris.* *Ufus*
promptus facit.

S E C T. XI.

Shewing the Use of Gunter's Qua-
drant, in taking the Declina-
tion of a Plane, by help of a
Horizonial Dial.

ON the back Side of the Quadrant,
you may draw a Circle, and di-
vide it into four 90 gr. or 360 gr. Draw
two Diameters, and to one of them
write *Axis* of the Plane, and the other
will cut it at the Right Angles in the
Center; to the Ends of these Diame-
ters, put four Capital Letters, E, W,
N, S, to signify East, West, North,
South: On the Center of this Circle,
let there be a small Pin, about two
Tenths of an Inch long, on which a
Horizontal Dial is to move; then, ha-
ving fixt your Quadrant-Edge to the
E 2 Plane,

Plane, whose Declination you are seeking, you must be very careful that it be horizontal, on which set your Horizontal Dial, (made for the same Latitude) and on the Meridian-Line of the Dial, let there be a small Tooth to point at the Degree of the Circle, on the back Side of your Quadrant. These Things being thus prepared, by your Quadrant find the true Hour of the Day, to which Time set the Horizontal Dial, that now moves upon the Center of the Circle, on the back of your Quadrant; and at the same Time will the Tooth or Index, that issueth from the Meridian Line of your Dial, cut the Circle in Degrees of the Planes Declination. This is a very plain and familiar Method, of finding the Declination of a Plane, and much easier than that found by the Sun's Azimuth, till you be well acquainted with Sphericks.

Here may seem some Difficulty to the young Tyro, in finding the Hour of the Day, if he has not got an Astronomical Quadrant, and well skill'd in Sphericks: But this Obstacle is soon removed by Help of an Universal Ring-Dial, such as is described in this Appendix;

Use of the Ring-Dial. 53

pendix; but then I advise it may be about nine Inches Diameter, for that is the best Size for this Purpose; for if it is any less, the Hours will be too small, to distinguish the Time to that Exactness, as is here required; and if the Diameter of the Dial be more, there will be too great a Penumbra attending the Ray of Light, that is cast upon the Equinoctial; therefore a Dial about nine Inches Diameter, seems to be the best for this Purpose.

S E C T. XII.

The Description of the Universal Ring-Dial, which sheweth the Hour of the Day in any Part of the World, and the Latitude also.

1. **T**HIS Instrument is generally known, and very useful for most Persons, and a Pocket Companion. It is projected out of two great

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54 *Use of the Ring-Dial.*

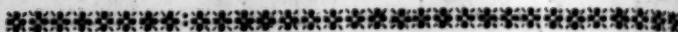
Circles of the Sphere ; also an Axis, and a little Ring to hang it by ; and the Making thereof is well known to the Workman. 2. The greater Circle is the grand Meridian, one Quadrant, or Quarter thereof, is divided into ninety Degrees, to set it to the Latitude of the Place wherever you are. On the other Side of the Meridian is a Quadrant of Altitude, to take the Height of the Sun, thereby to find the Latitude of the Place.

The lesser of these two Circles (though both represent great Circles of the Sphere) is the Equinoctial, divided into 24 equal Parts, or Hours, with their Halves and Quarters, which are numbred but from three in the Morning, to Nine at night ; the rest of the Hours are left out, being seldom or never used.

3. The Diameter, or broad Plate, hath a slit in the Middle, and upon one Side are the Months and Days of the Year, graduated to every fifth Day ; on the other Side is the Sun's Declination, from the Equinoctial to every fifth Day, which is to be used with the
Qua-

Quadrant of Altitude, to find the Latitude of the Place. The little Ring is made to slide along the Quadrant, with a small Tooth, to set it to the Latitude: And the Use of this Portable and General Instrument is as followeth.

S E C T.



S E C T. XIII.

The Use of the Ring-Dial in several Examples; first to find the Latitude, and secondly the Hour of the Day in any Place throughout the habitable World; and therefore an excellent Companion for all Travellers, Gentlemen, or others, of what Degree or Quality soever: 'Tis fit they should accommodate themselves with both this, and the Quadrant; the one being General, the other Particular; and the one supplies the Defects of the other.

1. *For the Elevation of the Pole, or the Latitude of the Place.*

FIRST, set the Hole in the moving Piece, (or Bride, so called by some) to the Day of the Month, then turn the other Side, and right against the Hole is the Sun's Declination for that

that Day. The same Day take the Sun's Meridian Altitude, (which is his Height at Noon every Day) and may be performed by this Instrument, thus: Put a Pin into the Hole, which you shall find in the greatest Circle; then move the Tooth to the beginning of the Degrees in the lesser Quadrant, and turn the Pin next to the Sun, and that Degree which is cut by the Shadow of the Pin, is the Sun's Altitude, (which must be taken just at Noon, as aforesaid.)

2. If the Time of your Observation be from the 10th of *March*, to the 13th of *September*, you must substract the Declination out of the Meridian Altitude of the Sun; but from the 13th of *September*, to the 10th of *March*, add, and the Sum, or Difference shall be the Complement of the Latitude, or Equinoctial Height, which being subducted out of 90 gr. leaves the Latitude of the Place.

EXAMPLE I.

1. Suppose the Latitude was unknown, and upon the 11th Day of *June*; you desire to find it then, by the

58 *Use of the Ring-Dial.*

the former Rule, find the Sun's Declination for that Day, which will be 23 gr. and 29 min. (or the Sun's greatest Northern Declination; then take the Sun's Altitude, just at 12 of the Clock, which at, and near *London*, will be found 61 gr. 57 m. then substract the Sun's Declination, 23 gr. 29 m. out of 61 gr. 57 m. and the Remainder will be 38 gr. 28 min. the Complement of the Latitude or Equinoctial Height, which subducted from 90 gr. leaves 51 gr. 32 m. for the Latitude of *London*.

EXAMPLE II.

2. As the former Directions shew how to observe the Latitude, the longest Day in the Year, when the Sun has his greatest Northern Declination; so here admit, that on the 10th of *December*, when the Sun's greatest Southern Declination is also 23 gr. 29 min. And the Meridian Altitude, but 14 gr. 59 m. add these two Numbers together, and they make 38 gr. 28 m. which deducted from 90 gr. leaves the Latitude as before.

2. *To find the Hour of the Day.* You must set the Tooth or Index, to the Height of the Pole, or Latitude of the
the

the Place, and slide the Hole in the Plate to the Day of the Month; then draw out the Equinoctial, or lesser Circle, and as near as you can guess at the Hour, and turn the Hole to it; then hold the Instrument by the little Ring, and move it till the Sun shine through the Hole, upon the middle Line in the Equinoctial, and that is the true Hour of the Day desired; and the Meridian, as it hangeth, lies in the Meridian of the World, truly North and South.

A N

APPENDIX.

The Use of Gunter's Line in measuring Board and Timber.

1. *Admit a Board be 10 Inches broad, and 20 Foot long, I demand the Content.*

Set one Foot of the Compasses in 12, and extend the other to 10; then set one Foot in 20, and extend the other back-

backwards, and it will fall in 16 Foot and a half, which is the Content of the Board required.

2. *Admit a Board be 15 Inches broad, and 27 Foot long, I demand the Content.*

Set one Foot in 12, and extend the other to 15; then set one Foot in 27, and extend the other forwards, and it will fall in 34 Foot which is the Content requir'd.

3. *Admit a Board to be 7 Inches and a half broad, and 29 Foot long, I demand the Content.*

Set one Foot in 12, and extend the other to $7\frac{1}{2}$; then set one Foot in 29, and extend the other backwards, and it will fall in 18 Foot, the Content required.

4. *Admit a Board to be 27 Inches broad, and 9 Foot and a half long, I demand the Content.*

Set one Foot in 12, and extend the other to 27; then set one Foot in $9\frac{1}{2}$, and extend the other forwards, and it will fall in 21 and a Quarter, which is the Content desired.

5. *Admit a Piece of Timber to be 18 Inches square, and 20 Foot long, I desire*

to know how many square Feet there is contained in this Piece of Timber.

Set one Foot in 12, and extend the other to 8, then set one Foot in 20, and extend that Distance twice backward, and it will fall in 8 Foot 3 Quarters, which is the true Content required.

6. *Admit a Piece of Timber to be 9 Inches and $\frac{1}{2}$ Square, and 27 Foot long, I demand the Content.*

Set one Foot in 12, and extend the other to $9\frac{1}{2}$, then set one Foot in 27, and extend that Distance twice backward, and it will be in 17 Foot, the true Content required.

7. *Admit a Piece of Timber to be 18 Inches square, and 9 Foot long, I demand the Content.*

Set one Foot of the Compasses in 12, and extend the other to 18, then set one Foot in 9, and extend that Distance twice forward, and it will fall in 20 Foot and $\frac{1}{2}$, the Content desired.

8. *Admit a Piece of Timber to be 22 Inches square, and 35 Foot long, I demand the Content.*

Set one Foot in 12, and extend the other to 22, then set one Foot in 35, and extend that Distance of the Com-

F

pas.

passes twice forward, and it will fall in 118 Foot, which is the Content required.

9. *Admit I have the Breadth of a Board in Inches, to find how much in Length will make a Foot superficial.*

Extend the Compasses from the Breadth to 12, the same will reach from 12 to the Content forward, if the Breadth be less then 12, and backward if the contrary.

S E C T. II.

Shewing the Use of the Carpenters Two-Foot-Rule, in the Mensuration of Board and Timber, &c.

BECAUSE cross Multiplication is better understood, and consequently imbraced by the common Artificers, than Decimal Arithmetick, I shall here subjoin a Table with Directions, for instructing those unacquainted with it, which is this :

Cross

Cross Multiplication-Table.

Factors	Feet	Inches	Parts	Seconds
Feet	Feet	Inches by 12	Parts by 12	Seconds by 12
Inches	Inches by 12	Parts by 12	Seconds by 12	Thirds by 12
Parts	Parts by 12	Seconds by 12	Thirds by 12	Fourths by 12
Seconds	Seconds by 12	Thirds by 12	Fourths by 12	Fifths by 12

Explanation.

1. Feet multiplied by Feet produce Feet.
2. Feet by Inches produce Inches, which divided by 12 give Feet.
3. Feet multiplied by Parts of an Inch, and divided by 12, are Inches.
4. Inches multiplied by Feet, and divided by 12, are Feet.
5. Inches multiplied by Inches, and that Product divided by 12, give Inches.
6. Inches multiplied by Parts produce Seconds, (or a Quantity less than

the Part of an Inch) which divided by 12 give Parts of an Inch.

7. Parts of an Inch multiplied by Feet, and divided by 12, give Inches.

8. Parts of an Inch, multiplied by Inches, and divided by 12, gives in the Quotient Parts of an Inch, and so on, as the Table expresseth, to Seconds, which are a Quantity 12 Times less, than the Parts of an Inch; as for Example: Let it be required to

	F.	I.	P.	
Multiply	5	3	6	
By	2	4	6	
<i>Operation.</i>				
	F.	I.	P.	
10	0	0		
0	6	0		
0	1	0		
1	8	0		
0	1	0		
0	0	2		
0	2	6	S.	
0	0	1	6	
0	0	0	3	
Product.	12	6	9	9

Note. In adding the several Parts together, you must carry 12 in all the Denominations.

Exam.

An Appendix.

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Example 2. Multiply me 7 Feet, 8 Inches, by 9 Inches, and 3 Parts.

Operation.

F.	I.	P.
7	8	0
0	9	3
5	3	0
0	6	0
0	1	9
0	0	2
Product.	5	10 11

Example 3.

	F.	I.	P.
Multiply me	0	11	9
By	0	5	0
	0	4	7 S.
	0	0	3 9
Product.	0	4	10 9

F 3

Example

Exam. 4. performed Duodecimally

			F.	I.	P.	S.
Multiply me	9	10	3	9		
By	8	11	9	6		
	4	11	1	10	6	
	7	4	8	9	9	
	9	0	5	5	3	
	78	10	6	0		
Product.	88	6	9	1	2	7 6

Note. You must begin with this Example at the right Hand, and carry the 12, as you do the tens in common Multiplication, and say 6 Times 9 is 54, that is 6 and carry 4 Twelves; then 6 times 3 is 18, and 4 I carried is 22, that is ten above 12, and carry 1 Twelve; then 8 times 10 is 80, and 1 I carry'd is 81, that is 1 and carry 6 Twelves; then 6 times 9 is 54, and 5 I carry'd is 59, that is 4 Feet and 11 Inches to set down, as you see in the Example: Then you must go on just thus with every one of the other Multipliers, which done, you must add the four several Products together, by carrying the 12, and then I find the Product to be 88 Feet, 6 Inches, 9 Parts (to $\frac{1}{4}$ of an Inch) 1 Second, 2 Thirds, 7 Fourths, and

6

6 Fifths, which is the exact Product of

F. I. P. S.

9 10 3 9

Multiply by 8 11 9 6

The like is to be observ'd of any other Feet and Inches whatsoever.

Being thus prepared with Duodecimal Arithmetick, commonly called Cross-Multiplication, you must in the next Place understand the Artificers common Two-Foot-Rule, which I thus describe. This Rule is made of dry Boxwood, two Foot long, with a strong Brass-Joint, to fold up to a Foot, for the Conveniency of the Pocket, on which there is a Line of Inches, numbred from one End to the other with Figures, 1, 2, 3, 4, &c. to 24; and each Inch is divided into 8 equal Parts, or half Quarters of an Inch; under this Line of Inches is placed the Line of Board-Measure, with the Table at the End, which is to shew how much in Length and Breadth will make a superficial Foot; and this Line is thus made, *viz.* As the Length or Breadth of the Board is to 1; so is 144 to the other; that is, If a Board be 8 Inches broad, how much in Length will make a Foot of that Board? *Opera-*

Operation.

As 8 : 1 :: 144 : 18. So 18 Inches in Length, and 8 in Breadth, is just one Foot of Board. So likewise, if the Breadth of a Board be 6 Inches, the Length to make a Foot; must be 24 Inches, or 2 Foot, and if the Breadth of the Board be 7 Inches, the Length of that, to make a Foot, must be 1 Foot, 8 Inches, and 6 Tenths of an Inch; but if the Breadth be only 5 Inches, then the Length of the Board, to make a Foot, must be 2 Feet, 4 Inches, and 8 Tenths of an Inch : As this Table, which is on one End of the Rule, more fully sheweth.

A Table of Board-Measure.

Inches	1	2	3	4	5	6	7	8
Feet	12	6	4	3	2	2	1	1
Inches	0	0	0	0	4.8	0	8.6	6

But when the Breadth of the Board exceeds the Table at the End of the Rule, then find it along the Side, and, right against the Inches of the Breadth, you will find, in the Line of the Board-Measure,

Measure, the Inches in Length of that Board, that will make a Foot; as, Suppose the Breadth of the Board be 10 Inches, what Length will make a Foot? Look for 10 Inch. in the Line of Inches, and right against, it in the Board-Measure Line, you will find 14 Inches, and 4 Tenths of an Inch, and so much in Length will make a Foot. Thus have I given you, the full Explanation of the Line of Board-Measure, and now I shall shew you its Use; how expeditiously to measure any Board, which is perform'd thus: Take the Rule in your Hand, and measure the Breadth of this Board, which I will here suppose to be 11 Inches, then look on your Board-Line, and see how much in Length, and that Breadth, will require to make a Foot, which you will find there to be 13 Inches, and one Tenth Part of an Inch. Lay your Finger at 13 Inches, and begin at the End of the Board, and measure along the Side, till you come to the other End; then, as often as you find 13.1 Inches, in the Length of the Board, so many Feet of Board is contained therein.

Exam-

Example 2. Suppose you measure with the Two-Foot-Rule, and find the Breadth of a Board, &c. to be 23 Inches, and look upon the Board-Measure Line, and find the Breadth of that Board that will make a Foot, which is $6\frac{1}{4}$ Inches; here hold your Finger, or mark it with Chalk; then begin at the End, and measure along the Board, and as often as you find $6\frac{1}{4}$ in the Length, so many Feet doth that Board contain.

If your Board to be measured be more than 24 Inches broad, so that you cannot see upon the Line of Board-Measure, how many Inches in Length goes to make a Foot of that Breadth; I say, in this Case, you must have recourse to the Proportion, made use of in making the Line above given, and then proceed to measure the Board as before. *Example:* There is a Table, whose Breadth is 27 Inches, and Length 7 Foot, how many Feet of Board doth it contain?

First find how much of that Breadth will make a Foot, thus,

As 27 : 12 :: 12 : 5.33. Or, as 27 : 1 :: 144 : 5.33. Here you see, that
5.33

5.33 Inches in Breadth, and 27 in Length is a Foot. Mark your Rule with Chalk at 5.33, and measure along the Side of the Table, and you will find it to contain 15 Feet, and almost three Quarters of a Foot.

The common Artificers Rule is now much improved, by adding a Slider in one of the Legs, which, if they do but take the Pains to understand, will much facilitate the Work of Measuring Superficies and Solids; and, for the sake of those that are unacquainted with it, I shall here give them, to understand, that the Lines, upon those Sliding-Rules, were the Invention of Mr. *Edmund Gunter*, and so are known, by the Name of the *Line of Numbers*, or *Gunter's Line*, being at first deduced from the Logarithms, which are composed of a single and double Radius, to slide by each other. The Radius is Divided into nine unequal Parts, in a Geometrical Proportion, and figured, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, called Primes.

These Divisions are again divided into 10 like Parts, called Tenths, and those again divided (where the first
Di-

Divisions are large) into five like Parts called Centisims. And the Figure, at the beginning of the Rule, towards the left Hand, may be either .1, 1, 10, 100, or 1000, then will the same Figure, in the Middle of the Rule, (when a double Radius) be 1, 10, 100, 1000, or 10000, and at the End, to the right Hand, 10, 100, 1000, 10000, or 100000, encreasing in a tenfold Proportion; which, being well understood, will give you the full Numeration upon the Rule. The next thing to be known is, how to multiply upon the Rule, which is thus perform'd: Set 1 upon the Slider to the Multiplicand upon the Stock, and against the Multiplier upon the Slider, is the Product upon the Stock. Or, you may take 1 upon the Stock, and the Multiplicand upon the Slider, and it will produce the same Thing.

Example. Let it be required to multiply 2 Feet, and a Quarter, by 5 Feet and a Half.

Operation.

Set 1 upon the Slider to 5.5 upon the Stock, (or to 2.25, it matters not

not which) and against 2.25 on the Slider, is 12.375, that is, 12 Feet and a Quarter, and half a Quarter of a Foot.

Other Examples:

Products.

$$\begin{array}{rcl} \text{Multiply} & \left\{ \begin{array}{l} 7.3 \\ 5.7 \\ 9.4 \end{array} \right\} & \text{by} \left\{ \begin{array}{l} 20.2 \\ 13.5 \\ 7.6 \end{array} \right\} \\ \text{me} & & \end{array} \begin{array}{l} 147.5 \\ 77 \\ 71.4 \end{array}$$

Division on the Sliding-Rule.

The Rule.

SET 1 on the Slider, to the Divisor on the Stock-Piece, and against the Dividend on the Stock-Piece, is the Quotient on the Slider.

Example. Let it be required to divide 12.375 by 2.25.

Operation.

Set 1 on the Slider, to 2.25 on the Stock-Piece, and against the Dividend 12.375 on the Stock, is 5.5 on the Slider.

G

Other

Other Examples.

$$\begin{array}{l} \text{Divide} \\ \text{me} \end{array} \left\{ \begin{array}{l} 147.5 \\ 77 \\ 71.4 \end{array} \right\} \text{ by } \left\{ \begin{array}{l} 7.3 \\ 5.7 \\ 9.4 \end{array} \right\} \left\{ \begin{array}{l} 20.2 \\ 13.5 \\ 7.6 \end{array} \right\} \text{ Qu}$$

Three Numbers given, to find a fourth in a Direct Proportion.

The Rule.

As the first Term upon the Slider, is to the second on the Stock; so is the third upon the Slider, to the fourth on the Stock.

Examp. If 10 Foot of Board cost 15s. what will 50 Feet cost at that Rate?

Operation.

Set 10 upon the Slider, to 15 on the Stock-Piece, and against 50 on the Slider, is 75 on the Stock, that is, 3l. 15s. the Price of the 50 Feet of Board.

Three Numbers given, to find a fourth in a Reciprocal or Inverted Proportion.

The Rule.

As the third Term upon the Slider is to the first upon the Stock; so is the second upon the Slider, to the fourth upon the Stock Piece.

Examp.

Example. If 6 Men can build a Wall in 9 Days, what Time will 3 Men be in doing the same.

Operation.

As 3 upon the Slider, is to 6 on the Stock; so is nine on the Slider, to 18 on the Stock; and that Time 3 Men will require to finish the same Work.

*To measure Board, or Glass, &c.
on the Sliding-Rule.*

AS the Length or Breadth in Inches, is to 144; so is the Length or Breadth in Inches, to the Content in Feet.

Example. Suppose a Board or Pane of Glass be $16\frac{1}{2}$ Broad, and $32\frac{1}{2}$ long, how many superficial Feet doth it contain.

Operation.

Set $16\frac{1}{2}$ on the Slider, to 144 on the Stock-Piece, and against $32\frac{1}{2}$ on the Stock, is 3 Feet and 7 Tenths of a Foot upon the Slider, the Answer sought.

G 2

Hay-

Having the Length and Breadth of any oblong Superficies in Feet, to find the Content in Feet.

This is no more, than to multiply the Length in Feet by the Breadth in Feet, and you will have the Content in Feet.

Example. Suppose the Breadth of a Board or Glass be $2\frac{1}{2}$, and the Length $17\frac{3}{4}$, how many Feet doth it contain?

As $1 : 2.5 :: 17.75 : 44.375$, that is, 44 Feet, and a Quarter and Half of a Foot, the Content.

Secondly, for Timber.

There is a Line upon the Artificer's Two-Foot-Rule, called the Timber Measure; the making of this Line is thus: As the Square of the Side, of any Piece of Timber or Stone, is to 1; so is the Cube of 12, viz. 1728, to the Length in Inches, that will make a Foot solid.

Example. Let the Side of a square Piece of Timber or Stone be $3\frac{1}{2}$ Inches, how many Inches in Length will make a solid Foot?

Operation.

First square $3\frac{1}{2}$ which is 12.25; then say, As 12.25 : 1 :: 1728 : 14.1, that is, 14 Feet, and one Tenth of a Foot, that Side will require to make a solid Foot. And after the same manner is the Line of Timber-Measure upon the Rule made.

The Use of the Line of Timber-Measure is this.

Suppose a Piece of Timber or Stone be 17 Inches square, at both Ends throughout, and 10 Feet long, how many solid Feet doth it contain? Look on the Line for Timber-Measure, and find how many Inches in Length will make a solid Foot, which you will find to be 5.97 Inches, which note; then begin at the End of the Timber, and measure along; for as often as you find 5.97 in the Length, so many Feet of Timber will you find contain'd therein, which in this Example is 20 Feet, and $\frac{10}{44}$ Parts of a Foot.

By the Sliding-Rule, two Operations at once setting the Rule.

Say, As 12 is to the Side of the Square 17; so is 10 Feet the Length, to a fourth

G 3

Num-

Number 14.1. Then, without stirring the Slider, say, As 12 is to 17; so is the fourth Number 14.1, to the Content in Feet, $20 \frac{12}{44}$.

Example. 2. In round Timber, it is the common Way, used amongst Artificers, to girt the Tree, and to take $\frac{1}{4}$ of that Girt for the Side of the Square; which let be 7 Inches, and the Length 20 Feet, what is the Content?

Operations.

As 12 : 7 :: 20 : 11.6.

Now say, As 12 7 :: 11.6 : 6.76 Feet.

Example. 3. Let the Side-Square be $8\frac{1}{2}$, and the Length 30 Feet, how many Feet is contain'd in this?

Operation.

As 12 : 8.5 :: 30 : 21.25

Now say, As 12 : 8.5 :: 21.25 : 15 Feet.

Also, let the Side-Square be 14, and the Length 36 Feet: Then,

As

As 12 : 14 :: 36 : 42.

Now say, As 12 : 14 :: 42 : 49 Feet.

Timber may be measured yet more expeditiously, than by what I have given above; for if your Rule has the Girt-Line on it, you may find the Content at one Operation. Now the Girt-Line is nothing else, but a single Line of Numbers, made to slide by the Side of a double Line of Numbers, and begins at 4, and continued to 40; this contains just one Radius of the Line, which answers to a double Line of Numbers; and the Reason of the Line being thus disposed, is because 40 Girt-Feet of Timber is a Load square. This known, girt your Timber about the Middle, a fourth Part of which is the Side of the Square; then measure the Tree in Feet, and say, As 12 on the Girt-Line, is to the Length in Feet on the Line of Numbers; so is $\frac{1}{4}$ of the Circumference on the Girt-Line, to the Content in Feet upon the Line of Numbers.

Example. Let the Circumference of a Tree be 100, one fourth of that

is 25 Inches, and the Length 12 Feet, how many solid Feet are there in this Timber?

Operation.

Leng. $\square$ *Con.*
As 12 : 12 :: 25 : 52 Feet.

Another Example.

Leng. $\square$ *Con.*
As 12 : 16 :: 20 : 44.4 Feet.

Example 3.

Leng. $\square$ *Con.*
As 12 : 17.5 :: 17.5 : 37.2 Feet.

N. B. But if it happen, that when 12 on the Girt-Line is set to the Length of the Tree, on the Line of Numbers, that then $\frac{1}{2}$ of the Circumference fall off the Line, to remedy this, there must be a new Gauge-Point found, to supply the old Gauge-Point 12, which is thus performed, viz. Set Unity on the Line of Numbers, to 12 on the Girt-Line, and against Unity on the Line of Numbers, you'll have the new Gauge-Point 37.95 on the Girt-Line,
with

with which work, as has been taught above with the Gauge-Point 12, and you'll have the true Content.

Example. Let the fourth Part of the Girt be 17.5 (as in the last Question) and the Length 17.5 Feet, what is the Content, by the new Gauge Point on the Girt-Line?

Operation.

Ga. Point. *Leng.* ☐

As 37.95 : 17.5 :: 17.5 : 37.2 Feet.

More Examples.

G. P. *Leng.* ☐

As 37.95 : 10.25 :: 13 : 12.1 Feet.

G. P. *Leng.* ☐

As 37.95 : 22 :: 9 : 12.3 Feet.

G. P. *Leng.* ☐

As 37.95 : 18 :: 11.5 : 16.5 : Feet.

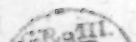
G. P. *Leng.* ☐

As 37.95 : 48 :: 14.75 : 72.8 Feet.

G. P. *Leng.* ☐

As 37.95 : 33.5 :: 20.25 : 96 Feet.

THE

A circular postmark from G. R. M. Co. with a central emblem. The text "G. R. M. Co." is arranged in a circle around the emblem. The emblem itself features a crown on top of a shield, which is flanked by two lions. The entire postmark is slightly faded and has a textured appearance.

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BY
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Vulgarly termed
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OF
ARITHMETICK,
AS,

*Multiplication, Division, and Extract-
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are performed with incredible Cele-
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ART

STARKING'S ART OF MEMORY
AND VEPIER BOXES
FOR THE USE OF THE MIND
AND THE MEMORY

PRINTED BY W. H. L.

FOR THE AUTHOR, BY J. W. STARKING, 10, N. B. ST. 1851



THE
ARGUMENT
TO THE
READER.

THE Right Honourable John Lord Nepeir, Baron of Merchiston in Scotland, in the Composure of those ever to be admired Tables of his Invention, called Logarithms, finding his Calculations so laborious in long and tedious Multiplications, Divisions, and Extracting of Roots, that his Invention to him must needs render itself very unpleasant, had he not known that the Labour when finished would crown both Him and his Work. He advised with divers learned Men, studious

H

in

To the READER.

in the Sciences Mathematical, and to them (and amongst them) especially to Mr. Henry Briggs, who (by a learned and able Divine) was styl- ed (and not without due Respect) our English Archimedes, to him, I say, this honourable Lord imparted his Invention, who joyning Issue with him, in this Herculean Labour, brought them to that Perfection to which they are now (to the Admira- tion of all Europe) arrived.

In the tedious Calculation of these Numbers, the Author finding his Work to go on but very slowly, at length, studying out for some Help by Art, to assist him in this his noble Enterprize, thinking upon several Helps, at last (by the Blessing of God) he hapned to find out this, which I here intend to describe and shew the Use of, with some Additions and Variation from what he has himself done, in his Treatise in Latin, published and printed at Edinburgh in Scot- land,

The ARGUMENT

land, Anno 1617, entitled, *Rab-*
dologiae seu Numerationes per Vir-
gulas. *The Uses whereof I shall, in*
the following Tractate, endeavour to
render so plain and easy, that he, that
can but Add and Substract, shall be
made able, in a Day's Time and less,
to Multiply and Divide any great
Numbers, nay, and to Extract both
the Square and Cube Roots.

I have begun this Treatise with
the Fabrick and Inscription of these
Rods, according to the Author's De-
scription, which being not so conve-
nient, either for Portability or Pra-
ctice, as some others which I have
seen and used, I have described them
(I think) in the best Manner they
possibly can be contrived.

For their Use, I am sure I have
done more than hitherto I have seen
done, and (if I mistake not) to as good
and effectual Purpose. I do not pub-
lish it as a Novelty, neither do I at-
tribute much in it to myself besides

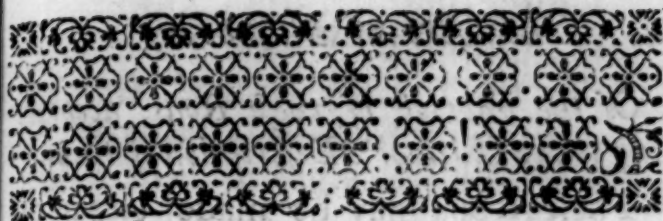
To the READER.

the Method ; for, had I not been desired, I should hardly have thought upon it : However, it being done, accept it and use it, till I direct something else to thee, which may be more acceptable, till when, I bid thee heartily



Farewel.

C H A P.



CHAP. I.

Concerning the *Fabrick and Inscription* Of these

R O D S.

IN the foregoing Argument I told you, that the Author and Inventor of this kind of Instrument, of which I intend to shew the Use, called it *Rabdologia*, and the Word he thus defines,

Rabdologia est Ars computandi per Virgulas numeratrices: That is, *Rabdologia* is the Art of Counting by numbring Rods.

I. *Of the Fabrick of these Rods, according to the Inventor's Description of them.*

These Rods may be made either of Silver, Brass, Box, Ebony, or Ivory, of which last Substance, I suppose, they were at first made, for that they are (for the most part) by all that know, or use them, called *Nepeir's Bones*.

But let the Matter of which they are made be what it will, their Form (according to this Description) is exactly a square Parallelepipedon, the Length being about three Inches, and the Breadth of them about one tenth Part of the Length. But the Length of these Rods are not confined to three Inches, but let the Length be what it will, the Breadth must be a tenth Part thereof; but that may be accounted a competent Breadth, that is capable of receiving two numerical Figures, for there is never upon one Rod required more to be set on the Breadth thereof.

The Breadth of these Rods, being exactly one tenth Part of the Length thereof, when 10 of these are laid together, they do exactly make a Geometrical

metrical Square, and if 20 of them be tabulated or laid together, they will make a right-angled Parallelogram, whose Length is double to its Breadth; if 30 be tabulated, the Figure will be still a Parallelogram, whose Length will be three Times the Breadth; and so if 40, four times the Length, & *fic. &c.*

The Rods being thus prepared of exact Length and Breadth, let each of them be divided into 10 equal Parts, with this Provifo, that nine of the ten Parts stand in the Middle of each Rod, and the other tenth Part must be divided into two Parts; half whereof must be set at the one End, and the other Half at the other End of the same Rod. Then from Side to Side draw right Lines from Division to Division, so is your Rod divided into Squares on every Side thereof. Lastly, from Corner to Corner of every of these Squares draw a Diagonal Line, and that will divide every Square into two Triangles. The Rods being thus prepared, and lined first into Squares, and then into Triangles, they are then fit to be numbred.

The

The Figure 1, at the beginning of the Book, shews the Form of one of these Rods lined as it ought to be.

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CHAP. II.

How these Rods are to be numbred.

IN the two half Squares, which are at the Ends of each Rod on every Side, there are set one single Figure, on each Side of every Rod one, in the Division at the End thereof; so every Rod containing four Sides, ten Rods will contain 40 Sides, and so consequently will have 40 single Figures at the Ends of every of them; that is, there will be upon the ten Rods amongst them four Figures of each kind, that is, four Ones, 1111; four Two's, 2222; four Threes, 3333; four Fours, 4444; four Fives, 5555; four Sixes, 6666; four Sevens, 7777; four Eights, 8888; four Nines, 9999; four Cyphers, 0000. And here it is to be noted, that what Figure soever it be, that standeth at the Top of the Rod alone, the Figure

by Speaking-Rods. 3

figure that standeth alone on the other Side of the same Rod maketh that Figure up the number 9. As for Example: If 1 stands on one Side, 8 will stand on the other Side, so 2 and 7 &c. as in this Table, where

1		8
2		7
3	stands alone	6
4	at the Top of	5
5	any Side of	4
6	any of the	3
7	Rods, then	2
8		1
9		0
0		9

This also is to be observed, in the Figuring of every Rod, that what Figure soever standeth alone at the Top, or superior Part of the Rod, the Figure, or Figures that stand in the two Triangles, next underneath it, is double to the Figure which standeth at the Top. And the Figures which stand in the next two Triangles below, that is three Times as much as the Figure above. And that in the

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the fourth Place, or Triangles, is four Times as much as the Figure above &c. till you come to the lowest Triangles in that Rod, and then the Figure, or Figures that stand in those Triangles, are nine Times as much as the Figure which standeth at the Top of the Rod.

So if a Rod have 4 at the Top thereof, the two Triangles, which are just and next under it, have only 4 in them, which is equal to 4; in the next two Triangles below there is 8, which is double to 4; in the two Triangles below them is 1 and 2, which together make 12, which is three Times as much as the 4 at the Top; the next Triangles have in them 16, which is four Times as much; the next 20, which is five Times as much; the sixth hath 24, which is six Times as much; the next Triangles have in them 28, which is seven Times 4; the next hath 32, which is eight Times as much; and the last Triangles at the bottom have 36 in them, which is nine Times as much. All which is visible by Figure II, at the beginning of the Book.

And.

And is evident enough by this little Table following, which is the Table of Multiplication, commonly called *Pythagoras's Table*.

The Figures in the									
First	Second	Third	Fourth	Fifth	Sixth	Seventh	Eighth	Ninth	
0	0	0	0	0	0	0	0	0	Figure at the Top of each Rod.
1	1	2	3	4	5	6	7	8	
2	2	4	6	8	10	12	14	16	
3	3	6	9	12	15	18	21	24	
4	4	8	12	16	20	24	28	32	
5	5	10	15	20	25	30	35	40	
6	6	12	18	24	30	36	42	48	
7	7	14	21	28	35	42	49	56	
8	8	16	24	32	40	48	56	64	
9	9	18	27	36	45	54	63	72	
Square which are									
Times as much as the Figure at the Top.									

Thus have you the *Fabrick, Inscription, and Numbring* of these Rods, according

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according to the Inventor's Contrivance of them. He makes mention of them, and hath in his Book set the Figure of the said Ten, of one of which Ten I have given you a Scheme at the beginning of the Book, which is Figure II. I will now proceed, to give you the Description of these Rods in another more commodious Form.

C H A P. III.

A Description of these Rods, according to their best and latest Contrivance.

THE Description, which I shall here give of these Rods, varies not at all from that before delivered in the Matter of which they are made, for these may be made either in Silver, Brass, Wood, Ivory, &c. Neither do they differ in their Dividing, nor yet in their Numbring: Only, whereas my Lord Nepeir maketh them square, each Rod to contain four Sides, these are made flat, consisting

sisting each Rod but of two Sides, and contain in Length about 2 Inches $\frac{2}{3}$, and in Breadth $\frac{1}{2}$ of an Inch, and in Thickness $\frac{1}{2}$ of an Inch.

One Set of these Rods consisteth of five Pieces, and therefore hath but ten Faces or Sides; whereas those of the Lord Nepeir's consisted of 40 Plains, or Sides.

Upon one of these five Pieces (a Figure whereof is at the Beginning of the Book, noted with Figure 3) you have a Cypher at the Head of the first Piece, and 9 at the Bottom thereof. Upon the second of them, you have 1 at the Head, and 8 at the Bottom; upon the Third, you have 2 at the Head, and 7 at the Bottom; upon the Fourth, 3 at Top, and 6 at Bottom; and upon the Fifth, you have 4 at the Top, and 5 at the Bottom. Every of the two Figures, at the Top and Bottom together, make 9; as 0, and 9 is 9, 1 and 8, 2 and 7, 3 and 6, 4 and 5. And here observe, that the Figures, 9 8 7 6 5, which stand at the Bottom of the Scheme, stand with their Heels upwards, in this manner, 6 8 4 9 5, so do all the other Figures.

I under

under them, till you come to the double Line, which is in the Middle of the Scheme, noted with *A* and *B*, at which Line, if the Scheme were cut into two Pieces, and folded or pasted on the Backside of the other Half, so that the 9 at the Bottom were placed upon the Cypher at the Top, and so 8 upon 1, 7 upon 2, 6 upon 3, and 5 upon 4; and then the Scheme cut again into five little Slippets, by the down-right Lines, these five Slippets would exactly represent one set of these Rods; for upon one of these Pieces, you should have a Cypher upon one Side, and 9 on the other; upon the next 1 and 8, upon another 2 and 7, on another 3 and 6, and on the other 5 and 4; both the Figures on either Side making 9, as before was described.

These five Slippets do now contain the whole Table of *Pythagoras* before mentioned, but so few are not of sufficient Use, neither are the Ten before mentioned of the Lord *Nepier's* Order; for their can be but four Figures of one kind, which in all Cases is not sufficient.

There-

Therefore as these Rods are made now-a-days, they do commonly make six Sets of them, that is, 30 Pieces, which contain 60 Faces, and these will be of good Use, and there will seldom be found a Want, which, in those of the Inventor's, there will often be ; except you have a great Quantity, which will be far more cumbersome, than these here described ; for there is required as much Metal, or Wood, in one of his, as in four of these ; and then, for his four Sides, we have here eight.

Concerning a Case for these Rods.

For the orderly keeping, and ready finding of these Rods, I have often (for myself and others) had a Box made of Walnut-Tree, or Pear-Tree, with five Partitions in it, each Partition to hold five or six Sets of these Rods, or more, if more Rods were required. Every of these Partitions being figured on the Side thereof next the Eye, with such Figures as the Rods in such a Partition had Figures at the Top, so that the Party, that was to use them, could take them as readily out of his Partition,

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tion, as a Printer can take his Letters out of his respective Boxes to make any Word.

In this Box there is also convenient Room made for one other Rod, double in Breadth to these here described; but of the same Length and Thickness; upon the one Side whereof there is a Table or Plate useful in the Extracting of the Square-Root, and on the other Side, another for the Extracting of the Cube-Root, the Figure whereof is at the beginning of the Book, noted with Square, Cube.

But I shall forbear to say any thing of them, till I come to shew you how to extract the Square and Cube Roots, by the Help of them and the Rods.

Of a Board with a Frame, upon which to lay your Rods, when any Operation is to be wrought by them, known by the Name of a TABULAT.

In the using of these Rods care is to be had, first, of the orderly laying of them; and then, secondly, for the keeping of them in that Position till your Work be ended. For the effecting whereof, both neatly and certainly, there

there is a little Table or Frame contrived, containing in Breadth $\frac{1}{2}$, of an Inch more than the Length of the Rods, and in Length at Pleasure, but it may well be about once and a half the Length of the Breadth.

It ought to be made of a thin Piece of Pear, or Walnut-Tree, or of such Matter as your Box or Case is made of; and it may very commodiously be contrived to be put into the Box, as I ever had them made to do, for that I found it inconvenient to carry loose.

Upon the Superficies of this Board, close to one of the Edges thereof, must be glewed, or otherwise fastned with Pins, a small Piece of the same Matter, and also of the same Length, Breadth, and Thickness of one of your Rods, which must be divided into 9 equal Parts, and Lines drawn cross the Piece; so will there be 9 Squares, in which you must grave or stamp the nine Digits, beginning with 1 at the Top, and so descending by 2 3 4 to 9 at the Bottom thereof: And it were necessary, that these Figures (as also those which are at the Head of every of your Rods) were graven or stamped of
I 3 some-

something a bigger Figure, than the other Figures of your Rods are.

Under the End of this Ledge, beginning at the Figures, and so continuing the whole Length of the Board, must another Ledge, of the same Matter and Thickness as the other, be glewed or pined, and then is your *Tabulat* finished. A Figure whereof you have at the beginning of the Book, noted with Figure 4. It is called a *Tabulat*, for that, when the Rods are laid thereon, for any Operation to be wrought by them, we usually say, the Rods are tabulated.

Being thus prepared with Rods and *Tabulat*, you are ready for the Work intended by them, and for which chiefly they were invented.

Thus much for the Fabrick, Inscription, and Numbring of these Rods; let us now come to shew the Uses of them.

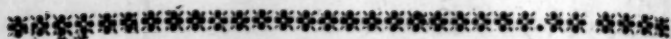
C H A P.

C H A P. IV.

To what Use these Rods generally serve.

THE chief Uses, to which these small Rods serve, I in part intimated at the Beginning, to which Effect I shall repeat it again—For by them all Manner of Multiplications and Divisions, as also of the Extraction of both the Roots, either Square or Cube, are so easily and expeditiously performed, and that by the Help of Addition and Subtraction only, that it is (as I may well say) inconceivable; for here is no Charge at all required of the Memory, and you shall assuredly take your Quotient-Figure in Division always certain, neither too great, nor too little, an Inconvenience so prejudicial, that I leave it to the Censure of such as have found it, to their great Loss of Time, and other Vexation which it hath put them to: But, ceasing to say more of their Properties, I will now come to shew their Use.

C H A P.



C H A P. V.

*How to apply, or lay down, any
Numbers by the Rods.*

P R O P. I.

*Any Number being given, how to
tabulate, or lay down the same
by the Rods.*

L E T it be required to tabulate, or
lay down this Number, 3496.

First, From among your Sets of
Rods (or out of your Case) take four
of them, of which let one of them have
the Figure 3 at the Top thereof, and
lay it upon your Tabulat, close to the
Edge thereof. Then,

Secondly, Take another Rod from
your Case, which hath the Figure 4 at
the Top of it, and lay that also upon
your Tabulat, close by the Side of the
other.

Thirdly, Take another Rod, which
hath the Figure 9 at the Top of it, and
lay

lay that upon your Tabulat, close by the other two.

And, lastly, take a fourth Rod, having the Figure 6 at the Head thereof, and lay that also upon your Tabulat, close by the rest.

These four Rods thus taken, and laid upon the Tabulat, you shall see in the uppermost Row (which standeth against the Figure 1, on the Side of your Tabulat) these four Figures, 3 4 9 6, that is 3496, equal to your given Number. In the second Row (against the Figure 2 of your Tabulat) you shall find the Double thereof. In the Third (against the Figure 3) you shall find the Triple thereof. In the Fourth, the Quadruple thereof. In the Fifth, the Quintuple; and so on to the Ninth and Last, in which you shall find the Non-cuple of the Number given

PROP.

P R O P: II:

How these Rods will appear when tabulated, and, being tabulated, how to read the Multiplication, of that Number so tabulated, by any of the nine Digits.

THE four Rods being tabulated, according to the Precepts delivered in the preceding Proposition, they will appear exactly as they are represented in Figure 4 at the Beginning of the Book, which Figure lively represents the four Rods lying upon the Tabulat, which mind well; for upon the true Tabulating, and right Reading of the Rods so tabulated, depend the whole Work.

The Rods thus tabulated, and as you see them in Figure 4, do to the Eye appear in the Form of a Glass-Window, every Pane thereof representing a Rhomboides, or Diamond-Form: In the Reading of the Figures which are in these several Rhomboides's, or Diamond-Forms, observe these few Directions

tions following, which will fully illustrate the whole Business intended, and therefore especially to be minded.

Note I. *That the Figures upon the Rods are to be read beginning at the right Hand, and reading towards the left; which is contrary to our common Course of Reading and Writing, which is from the left Hand towards the right.*

II. *That in every Rhomboides or Diamond, there are either one Figure, or two Figures, but never more than two.*

III. *If there be but one Figure in a Rhombus, then that Figure is the Figure to be set down alone, (be it either a Figure, or a Cypher) but if there be two Figures in a Rhomboides (as for the most part there is) then add them two Figures together, and set down their Sum in one Figure.*

IV. *But if the Sum of the two Figures, in one Rhomboides or Diamond, do exceed ten, then you must set down the overplus above ten, and keep one in Mind,*

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Mind, which one you must carry to the next Rhomboides.

V. That the first towards your right Hand, and the last towards your left Hand, are but half Rhomboides's or Diamonds, and never have in them more than one Figure; but all between them are whole ones, and for the most part have two Figures in them.

VI. If in either Rhomboides, or half Rhomboides, you find no Figures, but Cypbers, you must not neglect, but set them down as if they were Figures.

These Rules being rightly understood, all that follows will be familiar and easy, and these I shall explain by Example following.

Example.

For the Illustration of the preceding Rules, we will make use of those Rods which were before tabulated, therefore have recourse to Figure 4 at the beginning of the Book, where this Number 3496 is tabulated.

The Figures at the Top of the four Rods are these, 3 4 9 6, which signify the

the former given Number 3496, and this Number stands against the Figure 1 on the Side of the Tabulat. Then, I say, that the Figures in the next Row, standing against the Figure 2 of the Tabulat, are double thereunto, which I prove thus :

Repair to the Rods as they lie upon the Tabulat, and in that Row which lieth against the Figure 2, you shall find in the first half Rhomboides, towards your right Hand (where by Rule 1 you must begin) the Figure 2 ; wherefore set down with your Pen upon Paper the Figure 2 ; in the next Rhomboides, in the same Row, you will find 8 and 1, which added make 9, set down 9 on the left Hand of 2 ; in the next Rhombus you shall find 8 and 1 again, which is 9 also ; set down 9 on the left Hand of the other ; and in the last Rhomboides you shall find only 6, wherefore set down 6 on the left Hand of 9 : So have you in all 6992, which is double to 3496.

Again, the Figures in the Row, which stand against the Figure 3 in the Tabulat, are triple to 3496 ; for in the first half Rhomboides, towards your

K

right

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right Hand, you have 8, set down 8; in the next Rhombus you have 7 and 1, which is 8, set down 8 again; in the next you have 2 and 2, which is 4, set down 4; in the next Rhombus you have 9 and 1, which makes 10, set down 0 and carry 1; but it is the last Rhombus, and because there is never another to carry the 1 unto, you must therefore set it down: So have you this Number 10488, which is triple to 3496.

Again, the Figures standing against 4 in the Tabulat are Quadruple to 3496; for in the half Rhombus you have 4, set it down; in the next 6 and 2, which is 8, set that down; in the next 6 and 3, which is 9, set that down; in the next 2 and 1, which is three, set that down; and in the last half Rhomb. you have 1, which also set down: So have you 13984, which is quadruple to 3496.

Also, of the Figures against 5 in the Tabulat, the first is a Cypher, therefore put down 0; the next is 5 and 3, which is 8, set down 8; the next is 0 and 4, set down 4; the next is 5 and 2, that is 7, set down 7; and the last is 1, there-

therefore set it down : So have you in all 17480, which is Quintuple to 3496.

Against 6 in the Tabulat, you have in the first place 6, set it down ; then in the next 4 and 3, that is 7, set that down ; in the next 4 and 5, that is 9, set 9 down ; in the next you have 8 and 2, that is 10, set down 0 and carry 1 to the next Rhomb. where you find only 1, to which add the 1, which you carried from the Rhomb. before, and it makes 2, set down 2 : So have you 20976, which is six times 3496.

Against 7 in the Tabulat you have first 2, set it down ; then 3 and 4, which is 7, set 7 down ; in the next, 8 and 6, which is 14, which being above 10, set down 4, and carry 1 to the next Rhomb. where you have 2 and 1, which is 3, and 1 which you carried makes 4, set down 4 ; then in the last Place you have only 2, which set down : So have you in all 24472, which is septuple to 3496, or seven times as much.

Against 8 in the Tabulat you have first 8, which set down ; then 2 and 4, which is 6, set 6 down ; then 2 and 7, which is 9, set 9 down ; then 4 and 3, which is 7, set 7 down ; and lastly 2,

K 2

set

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set that down: So have you 27968, which is octuple to 3496, or eight times as much.

Lastly, against 9 in the Tabulat, you have in the first Place 4, set that down; in the next you have 1 and 5, which is 6, set 6 down; in the next place you have 6 and 8, which is 14, set down 4, and carry 1 to the next Rhomb. where you find 7 and 3, that is 10, which with 1 that you carried makes 11, set down 1, and carry 1 to the next Rhomb. where you find only 2, and the 1 carried makes 3, therefore set down 3: And so you have 31464, which is noncuple to 3496, or nine times as much as the tabulated Number.

Thus have I given you Examples, in shewing you how the Numbers upon the Rods are to be read and written down; and in the Delivery of this Example, I have made the whole Work, which is to follow, so plain and easy, that the meanest Capacity (I think) if he can but tell his Figures, and add any two Figures together, he may, by this here delivered, read or write down any Number that can be tabulated: And,
that

by Speaking-Rods. 25

that you may thoroughly understand this Chapter before you proceed further, I will give you the Products of 7009078, multiplied by all the nine Digits, which I would have yourself to tabulate, and see if you find your Working by your Rods to agree with those which are here written, which Numbers if they do, you need not scruple at the most difficult that can be proposed to you; therefore study it, and try it.

7009078

7009078 being mul- tiplied by	{	2	}	Produce	{	14018156
		3				21027234
		4				28036312
		5				35045390
		6				41054468
		7				49063546
		8				56072624
		9				63081702

Thus have I sufficiently described these Rods, and the Manner of Numbring upon them; and now I think it Time to apply them to that Use for which they were intended; namely, the more difficult Parts of Arithmetick, as

K 3

Mul.

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Multiplication, Division, and Extraction of Roots; but first let me give you

An Admonition concerning Addition and Substraction.

Whereas it was the difficult Operations of *Arithmetick*, which, by the Benefit of these Rods, the Inventor chiefly aimed at (of which Kind he esteemed *Multiplication, Division, and Extraction of the Square and Cube Roots*) he omitted to say any Thing concerning *Addition and Substraction*, as Things obvious to every *Tyro*: He therefore omitting them, begins to shew the Use of his Rods in *Multiplication*, whose Method I shall here follow.

C H A P. VI.

Multiplication by the Rods.

IN multiplying by the Rods, you are to consider (as in *Vulgar Arithmetick*) three Terms, Things, or Numbers, viz.

1. The *Multiplicand*, which is the Number to be multiplied.

2. The

2. The *Multiplier*, which is the Number by which the *Multiplicand* is multiplied.

3. The *Product*, which is the Sum produced by the Multiplying of the two former together.

And here note, That the *Product* doth contain the *Multiplicand*, so many Times as there be *Unites* in the *Multiplier*.

Thus for the Definition of *Multipli- cation*: Now for the Working thereof by the Rods; for which this is

THE RULE.

First, Set down upon your Paper the *Multiplicand*, and orderly under it the *Multiplier*. [It matters not greatly which of the two given Numbers be made *Multiplicand* or *Multiplier*; but it is usual and best to make the greatest Number *Multiplicand*, and the lesser *Multiplier*.] Then draw a Line with your Pen under them, and having tabulated your *Multiplicand* (or greater Number) look what Numbers in your Rods stand against the first Figure towards your right Hand, and that Number which you shall find upon your Rods standing against that first Figure found in your Tabulat, set

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Set down under your Line, which you formerly drew under your Multiplicand and Multiplier; and having so done with the first Figure of your Multiplier, do so with the rest, setting them down one under another, removing every Figure one Place more towards the left Hand, than that which went before it, as is done in common Multiplication, and as you see in the following Example.

Example 1. Let it be required to multiply 3496, by 489. As if it were required to know how much 489 Times 3496 would amount unto.

First, Set down your given Numbers 3496, and 489, one under another, and draw your Line under them, as here you see done.

Secondly, 3496, your Multiplicand, being tabulated, and 9 being the first

3496 Multiplicand
389 Multiplier

31464
27968
13984
1709544 Product.
Sec.

Figure to
the right
Hand in
your Multiplier,
look upon
your Rods,
what Sum
there

there stands against 9 in the Side of your Tabulat, and you shall find (as by the Rules in the second Prop. of the fifth Chap. you was directed) 31464, which is the Product of 3496, multiplied by 9; wherefore set down this Number 31464 under your Line, as you see in the Example.

Thirdly, Look what Sum upon the Rods stands against 8, which is the second Figure of your Multiplier, and you shall find 27968; set this Number under the former, moving it one Place forward towards the left Hand.

Fourthly, Look what Sum upon the Rods stands against 4, which is the third Figure in your Multiplier, and you shall find 13984, which set down under the other, one Place more to the left Hand.

Lastly, Under these three Sums draw a Line, and add the three Sums together, and they make 1709544, which is the Product of 3496, multiplied by 489; and this 1709544, the Product, contains 3496, the Multiplicand, 489 Times.

Practise well this first Example, and compare it with the Rods as they are tabulated in Figure 4, at the beginning
of

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of the Book, as also with the Rules in the fifth Chapter, and you may perform any Multiplication. However, I will give you one or two more Examples, and some other Ways of *Multiplication*.

Example 2. Let it be required to multiply the same Sum 3496 by 261.

$ \begin{array}{r} 3496 \\ 261 \\ \hline 3496 \\ 20976 \\ 6992 \\ \hline 912456 \end{array} $	Set the Numbers down as here is done, then look upon the Rods for the Product of 3496 by 1, and you shall find it to be the same, wherefore set down 3496 under the Line. — Then look upon
--	---

the Rods for the Product of 3496 by 6, and you shall find it to be 20976, which set down under the other Number, one Place more towards the left Hand. — Again, look in the Rods for the Product of 3496 multiplied by 2, and you shall find it to be 6992, which set down under the other two.

Lastly, Draw a Line under them, and add the three Numbers together in order as they stand, and the Sum of them will be 912456, which is the Product of 3496, multiplied by 261.

Exam.

Example 3. Let it be required to multiply the same Number 3496 by 520.

Set down your Numbers as here you see done : — Then, because the first Fi-

3496		figure of your Multiplier, to-
520		wards your right Hand, is a
6992		Cypher, wholly omit it, and
17480		multiply 3496 by 52 only, so
1817920		shall you find the Product of

3496 by 2, to be 6992, which set down : Also the Product by 5 will be 17480, which set down under the other one Place further ; then draw a Line —, and add these two Sums together, and they make 181792, to the which, if you add a Cypher for the Cypher which you omitted in your Multiplier, the Sum will be 1817920, which is the Product of 3496 by 520.

Example 4. Let it be required to multiply the same 3496 by 7003.

Set down your Numbers as before, and as you see here done ; then, having

3496		tabulated 3496, see what the
7003		Product thereof is upon the
10488		Rods, being multiplied by 3,
24472		the first Figure in your Mul-
24482488		tiplier, and you shall find it

to be 10488, which set down under

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under the Line : — Then the two next Places of your Multiplier being Cyphers, make two Pricks under the former Number, one under 8, the other under 4, as you see in the Example, or instead of 2 Pricks, you may make two Cyphers : — Then look on the Rods for the Product of 3496 by 7, and you shall find it to be 24472, which set down under the other Sum, beginning your Number at the fourth Place, or beyond the two Pricks or Cyphers. Lastly, Draw a Line, and add these two Sums together, and their Sum is 24482488, which is the Product of 3496 multiplied by 7003.

Thus have you four Examples in *Multiplication*, in which are included all the Varieties that may at any Time happen in that Rule, viz. Two, where the Multiplier consisted all of Figures, as in the first and second Example they did. — Another, where the latter Place of a Multiplier consisted of a Cypher. — And this last Example, where Cyphers were intermixed among the Figures.

And thus much for this Kind of Multiplication ; but, before I leave, I will shew you

Ano-

Another Form of Multiplication.

Whereas, in the foregoing Form of Multiplication, which is the best and most usual, (only I insert this following for Variety) you began (your Rods being tabulated) with that Figure of your Multiplier, which stands next your right Hand; but there is no necessity for that, for you may begin with that Figure which standeth next to your left Hand, and by so doing, and placing your several Products one Place more to the right Hand, as you did before place them to the left Hand, those Products added together in the Form they then stand, shall produce a Product equal to the former.

Example. For our Example we will take the first Example foregoing, at the beginning of this Chapter, where it was required to multiply 3496 by 489. Set the Numbers down as before in that first Example, and as you see here done—

L 3496

3496	Then 3496 being tabulated,
489	look upon your Rods for the
13984	Product thereof, multiplied
27968	by 4, (which is the first Fi-
31464	gure of your Multiplier to-
1709544	wards your left Hand) and
	you shall find the Product

thereof to be 13984, which set down.

— Secondly, look the Product of 3496 by 8 (your second Figure) and you shall find it to be 27968, which must not be set down as in the other first Example, but as you see it in this; 8, the first Figure thereof, must be set one Place forward towards the right Hand, as in the other, it was set a Place backward towards the left. — Lastly, seek in your Rods for the Product of 3496 by 9, your last Figure, and you shall find it to be 31464, which set under the other two Numbers, yet one Place more to the right Hand. — So a Line being drawn under, and these three Numbers added together, produce 1709544, equal to that in the first Example: And that you may the better see the Difference of the Work, I have set them one by the other.

As in the
first Ex-
ample,

$$\begin{array}{r} 3496 \\ 489 \\ \hline 31464 \\ 27968 \\ \hline 13984 \\ \hline 1709544 \end{array}$$

As in this
Example,

$$\begin{array}{r} 3496 \\ 489 \\ \hline 13984 \\ 27968 \\ \hline 31464 \\ \hline 1709544 \end{array}$$

One Example more in Multiplication (which shall be for Advertisement and Direction) I will give, and so conclude Multiplication.

I said, in the general Rule for working of Multiplication (at the beginning of this Chapter) that it mattered not which of your Numbers were made the Multiplicand, or which the Multiplier, of which I will here give you a President, where the lesser Number shall be tabulated, and the greater Number only set down; and I will work it here according to this last Way of Multiplication, and the Example shall be as followeth.

Example. Let it be required to multiply 868437 by 3496, and let 3496 (the lesser Number) be tabulated.

L. 2

Let

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Let the Numbers be set as you here see, then 3496 being tabulated, begin with the first Figure towards the left

$$\begin{array}{r}
 3496 \\
 868437 \\
 \hline
 27968 \\
 20976 \\
 27968 \\
 13984 \\
 10488 \\
 24472 \\
 \hline
 3036055752
 \end{array}$$

Hand of your Multiplier, which here is 8, and upon your Rods find the Product of 3496 multiplied by 8, which is 27968, set that down under the Line.—Then find the Product of 3496 by 6, the second Figure of your Multiplier, and

you shall find that to be 20976, set this Number under the former, one Place more towards the right Hand.

— Again, the third Figure of your Multiplier is 8, whose Product is 27968, as before, set that under the other, still one Place more to the right Hand.—

In this Manner do with the other Figures of the Multiplier; as 4, the next Figure, whose Product is 13984, which also set down a Place forward. — So also the Product of 3, which is 10488, which set down. — And lastly, of 7, which is 24472. —

All these Products being set down in the Order as you see them in the Margent, if you add

add them together, the Sum of them will be 3036055752, which is the Product of 3496, multiplied by 868437, the lesser Number being tabulated.

Other Ways of Multiplication I could have added, but these I esteem sufficient.

CHAP. VII.

Division by the Rods.

AS in Multiplication, so in Division, there are three Numbers, Terms, or Things required, viz.

1. The Dividend, or Number to be divided.

2. The Divisor, or Number by which the Dividend is divided ; and,

3. The Quotient, which is the Number issuing from the Dividend's being divided by the Divisor ; and this Quotient doth always consist of so many Unites, as the Divisor is Times contained in the Dividend.

Thus much for the Definition of Division, now let us come to the Practice

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of it by the Rods, to perform which, his is

THE RULE.

Tabulate the Divisor, (which is always the lesser Number of the two given) and set down the Dividend, and set the Divisor on the left Hand, and draw a crooked Line on the right Hand for your Quotient, as in common Arithmetick; then look upon your tabulated Rods (always) for the Number, less than the Number in the first Figures of your Dividend, and what Figure stands against that Number, on the Edge of your Tabulat, must be the Figure you must put in your Quotient; and that Number you must always subtract from the Figures of your Dividend, and to the Remainder add another Figure, so proceeding from Figure to Figure, till your Division be wholly ended.

Example. Let it be required to divide 1709544, by 3496. Having tabulated 3496, set down your Dividend, your Divisor on the left Hand thereof, and a crooked Line for the Quotient on the right Hand thereof, as by the Rule preceeding you were directed, and as you

you see done in the Example adjoining.

And because, at your first setting down of your Divisor 3496, it would reach (if it were set under your Dividend 1709544) as far as the Figure 5, therefore under the Figure 5 make a Prick, to intimate how far you are gone on in your Work, and under this Prick, draw a Line quite under your Dividend, then is your Sum set down ready for Work, and will appear as you see here,

3496) 1709544 (

Your Sum thus prepared, ask how often can have you 3496 in 17095? look in your tabulated Rods for 17095, which you cannot there find, but the nearest Number thereunto among the Rods, which is less than 17095 (for you must always take a less Number) is 13984, which Number stands against the Figure 4 in the Tabulat, wherefore set 4 in your Quotient, and 13984 under the Line, and subtract 13984 from 17095, and there will remain 3111; so

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so is the first Part of your Division ended, and your Work will stand thus,

$$\begin{array}{r} 3111 \\ 3496 \overline{) 1709544} \quad (4 \\ \underline{13984} \end{array}$$

Then make another Prick under 4, the next Figure of your Dividend, so will the remaining Number be 31114: — Then look among the Rods for the Number 31114 (or the nearest less than it) and the nearest less you shall find to be 27968, which stands against 8 in your Tabulat, put 8 in your Quotient, and set 27968 under 31114, and subtract 27968 from 31114, so will there remain 3146, which set over Head; so is the second Part of your Division ended, and your Work will appear thus,

$$\begin{array}{r} 3146 \\ 3111 \\ 3496 \overline{) 1709544} \quad (48 \\ \underline{13984} \\ 27968 \end{array}$$

Lastly,

Laſtly, Make another Prick under the next Figure of your Dividend, which is 4 alſo, making the remaining Number to be 31464, ſeek among your tabulated Rods for this Number (or the neareſt leſs) but looking, you ſhall find the very Number, againſt which ſtands on your Tabulat the Figure 9, ſet 9 in the Quotient, and the Number 31464 under the Line, and ſubſtract it from 31464 the Remainder, which ſtands above the Line, and nothing remains; and being there is never another Figure in your Dividend, your Division is ended, and your Work will ſtand thus; and 3496 is contained in 1709544 489 times.

$$\begin{array}{r}
 \text{Diviſor} \quad 3146 \quad \text{Quotient} \\
 3496 \overline{) 1709544} \quad (489 \\
 \underline{13984} \\
 27968 \\
 \underline{31464}
 \end{array}$$

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*Another Example, and by another Way
of Division.*

Let it be required to divide 912456 by 3496, set down your Dividend and Divisor, draw a crooked Line for your Quotient, and also make a Prick under the fourth Figure of your Dividend, and draw a Line under your Dividend; so is your Sum prepared to be divided, and will stand thus,

$$3496 \overline{) 912456}$$

Then your Divisor 3496 being tabulated, look amongst your Rods for the nearest Number to 9124, which is less, and you shall find it to be 6992, against which stands on your Tabulat the Figure 2; set 2 in the Quotient, and this Number under the Line, and subtract it from 9124, and there will remain 2132, to which Number add the next Figure of your Dividend, namely 5, and it makes 21325; under which Number draw a Line, then will your Sum stand thus,

3496

3496) 912456 (2

6992

21325

Then among your Rods seek the nearest Number to 21325, and you shall find 20976 to be the nearest Number less, against which in your Tabulat stands 6; set 6 in the Quotient, and 20976 under the Line, subtracting it from 21325, which, when you have done, there will remain 349; to 349 add the next Figure in your Dividend, which is 6, your last Figure, and it makes 3496, under which draw a Line, and your Work will stand as you see here,

3496) 912456 (26

...

6992

21325

20976

3496.

This

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This done, look amongst your Rods for the nearest Number to 3496, and you shall find the exact Number at the Top of the Rods, against which stand, the Figure 1 on the Tabulat; set 1 in the Quotient, and subtract 3496 from 3496, the Remainder is nothing; and so is your Division ended, the Work standing thus, and 3496 the Divisor, is contained in 912456 the Dividend, 161 times.

3496) 912456 (361

6992

21325

20976

3496

3496

0000.

A third Example ready wrought by the last and best Way of Division.

I will only set it down ready wrought, leaving the Practice of it to yourself.

Let

by Speaking-Rods. 45

Let it be required to divide 73020506
by 3496.

$$3496 \overline{) 73020506} \quad (20886 \frac{1050}{3496})$$

6992

31005

27968

30370

27968

24026

20976

Rem. 3050

This Sum thus divided produceth in
the Quotient 20886, and 3050 remain-
ing; so that the Quotient with Frac-
tion and all is

20886 $\frac{1050}{3496}$, which shews

that 3496, the Divisor, is contained in
73020506, the Dividend, 20886 times,
and 3050 remaining.

M

This

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This Example well practised, together with them foregoing, are sufficient Instructions for any Student whatever; and he that can perform these, need not despair the most difficult that can be proposed. And so I conclude with Division.

C H A P. VIII.

Concerning the Rule of Three, or Golden Rule, both Direct and Reverse, or Reciprocal.

TO discourse of this Rule at large, were to run into a Labyrinth; for it was the Performance of Working Multiplication and Division by the Rods that was here aimed at, and he that can multiply and divide, may command this *Golden Rule*: Wherefore I will shew you the Nature or Order of Placing the Numbers, and also the Manner of Working an Example in either of them.

The *Rule of Three* is that Rule which teacheth, by having three Numbers, in Proportion one to another given, to find

And a fourth, which shall be in Proportion to them also.

In this *Rule direct*, the fourth Number which is sought, is to have the same Proportion to the third, as the second Number hath to the first: As if the three Numbers given were 2—4—and 8; say, as 2 is to 4, so is 8—to what? Multiply 4 by 8 (that is, the second Number by the third) and the Product will be 32, which divide by 2 (the first Number) the Quotient will be 16, which is the fourth Number in Proportion to the third, as the second is to the first; for as 4 the second Number, contains 2 the first Number twice; so 16 the fourth Number, contains 8 the third Number twice also.

But in the *Reciprocal Rule of Three*, there the Proportion is not as the first to the second, so the third to the fourth: But as the first is to the third, so is the second to the fourth. As if the Numbers were 3, 4, and 6, say, as 3 the first Number, is to 6 the third Number, so is 4 the second Number, to what? Multiply 4 the second Number, by 3 the first Number, the Product is 12, which divide by 6 the third Number,

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ber, and the Quotient will be 2; for as 6 the third Number, contains 3 the first Number twice, so 4 the second Number, contains 2 the fourth Number twice also: And in this consists the Difference between the *Direct* and *Reciprocal Rule of Three*.

Questions in each Rule: And

1. In the *Direct Rule*.

If four Men eat two Pecks of Corn in one Week, how many Pecks will serve an hundred Men the same Time?

Men	Pecks	Men
4	2	100

Multiply 2 the second Number by 100 the third Number, the Product will be 200, which divide by 4 the first Number, and the Quotient will be 50, and so many Pecks will suffice 100 Men the same Time.

2. In the *Reciprocal*.

If twelve Men do any Piece of Work in 8 Days, how many Men must be employed to do the same Piece of Work in 2 Days.

Days.

Days	Men	Days
8	12	2

Multiply 8 the first Number, by 12 the second, their Product is 96, which divide by 2 the third Number, the Quotient will be 48, and so many Men will do the same Work in 2 Days ; for as 8 Days are to 2 Days, so are 12 Men to 48 Men, &c.

C H A P. IX.

Of the Extraction of Roots.

THE Extraction of *Roots*, which is the difficultest Part of Multiplication and Division, is expeditiously and certainly performed by the Rods ; for the easy and expedite Performance of which, there are two Rods on purpose, one for the Square, the other for the Cube-Root, of which I will speak ; first, of their Fabrick ; secondly, of their Use.

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Of the Fabrick of the Rods for Extracting of Roots.

Of the same Matter, and of the same Length and Thickness of your other Rods, let there be made another Rod, but three Times the Breadth of the former; the Inscription on one Side serving to extract the Square, and that on the other Side for the Cube-Root, each of which are divided into three Rows or Columns.

That which serveth for the Square-Root hath in the Top, or uppermost Square between the Diagonal thereof, these Figures 0-1, in the second 0-4, in the third 0-9, in the fourth 1-6, in the fifth 2-5, in the sixth 3-6, in the seventh 4-9, in the eighth 6-4, and in the ninth or lowermost 8-1, which are the Square Numbers belonging to the nine Digits.

In the second Column of the same Rod, in the first Square is inscribed 2, in the second 4, in the third 6, in the fourth 8, in the fifth 10, in the sixth 12, in the seventh 14, in the eighth 16, and in the ninth 18.

In the last or third Column, there are the nine Digits orderly descended; namely,

by Speaking-Rods.

51

namely, 1, 2, 3, 4, 5, 6, 7, 8, 9. This Rod thus made is fitted for the Square-Root.

That which serveth for the Cube-Root hath in the Top, or uppermost Square of the first Column towards the left Hand, between the Diagonal thereof, these Figures, 0-01, in the second 0-08, in the third 0-27, in the fourth 0-64, in the fifth 1-25, in the sixth 2-16, in the seventh 3-43, in the eighth 5-12, and in the ninth 7-29, which are Cube Numbers orderly descending. — The second Column of this Rod contains these Square Numbers, 1, 4, 9, 16, 25, 36, 49, 64, 81, orderly descending. — The third and last Column of this Rod hath in it the nine Digits, 1, 2, 3, 4, 5, 6, 7, 8, 9, orderly descending also.

This Rod thus prepared and inscribed is fit for Extracting of the Square and Cube-Roots, a Figure of either Side whereof you have at the Beginning of the Book: That which serveth for the Square-Root, having the Word *Square* written over Head; that for the Cube-Root, hath *Cube* written over Head.

Thus having given you the Fabrick and Inscription of the Rods, I will now shew you their Use; and first,

Con.

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Concerning the Extraction of the Square-Root.

In Extracting of the Square-Root, you must, as in common Arithmetick, when you have set down your Number, make a Prick under the first Figure towards your right Hand, and so successively under every second Figure; then under those Pricks draw two Lines parallel, whereinto set the Figures of your Root as you find them: Your Number being thus placed and pricked as before is directed, and as in the following Example you see done, you may proceed to extract the Root thereof as followeth.

Example 1. Let it be required to find the Square-Root of this Number 12418576; first, make a Prick under 6, another under 5, another under 1, and another under 2, under which Points draw two Lines, in which you must place your Root, and then will your Number stand thus,

12418576

• : • •

Take the Rod for Extracting of the Square-Root, and look in the first Row
or

or Column thereof, for the nearest Number you can find there less than 12, (which is as far as the first Prick in your Number reaches) and you shall find 9, against which in the third Column you shall find three, set 3 under the first Point between the Lines, and 9 under the Line; and, subtracting 9 from 12, there will remain 3, which set over 12, so will your Number stand thus:

$$\begin{array}{r}
 3 \\
 12418576 \\
 \hline
 3 \\
 \hline
 9
 \end{array}$$

Then in the middle Column of your Rod, between 9 and 3, there stands 6; take therefore one of your-Rods which hath 6 at the Top there-

of, and lay it upon your Tabulat by the left Side of your Square Rod, then being there is 341 to the next Prick, seek the nearest Number less upon your two Rods, and you shall find the next less to be 325, against which, in the last Column of your Square-Rod, stands 5, therefore place 5 under your second Prick, and set 325 under 341, and subtracting it from 341, there will remain 16, which set over Head, then will the Sum appear thus:

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16
 3
 12418576

 3 5

 9
 325

And in the middle Column
 of your Square-Rod a-
 gainst this 5, there stands
 10; for this 10 you should
 take a Rod that hath 10
 at the Top, but being
 there is no such, take
 therefore one that hath a

Cypher, and place that between your
 Square-Rod and your Rod of 6, and
 change your Rod of 6 for one of 7, then

Thus must you al-	shall you have up-
ways do, when the	on your Tabulat
Number in the mid-	one Rod of 7, a-
dle Column exceeds	nother of 0, and
10.	your Square Rod.

Then, looking upon your Sum, you
 shall find 1685 to your third Prick, look
 therefore upon your Rods for the near-
 est less Number, which you shall find
 to be 1404, against which stands 2
 in the last Column, set 2 between the
 Lines under the third Prick, and
 1404 under 1685, and, subtracting it
 from 1685, there will remain 281, which
 place above, so will your Sum stand
 thus:

281

$$\begin{array}{r}
 281 \\
 16 \\
 3 \\
 12418576 \\
 \cdot \cdot \cdot \cdot \\
 \hline
 3 \ 5 \ 2 \\
 \hline
 9 \\
 325 \\
 1404
 \end{array}$$

And because the Number, standing against in the middle Column of your Square Rod between 1404, and 2 was 4, set 4 under your last Prick, and take a Rod of 4, and put it between your Square Rod, and your Rod of 0; and because 28176 remains upon your Sum to the last

Prick, look upon your Rods for the nearest Number thereunto, and you shall find the very Number it self to stand against the Figure 4, set therefore 28176 below, and substract it from that above, and there will remain nothing, which denotes the Number 12418576, to be a square Number, and the Root thereof to be 3524, and the Work finish'd will stand thus :

00000

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$$\begin{array}{r}
 00000 \\
 281 \\
 16 \\
 3 \\
 \text{Square } 12418576 \\
 \hline
 3 \ 5 \ 2 \ 4 \ \text{Root,} \\
 9 \\
 325 \\
 1400 \\
 28176
 \end{array}$$

This Sum, had it been wrought by the second Way of Division, which I shewed in Chapter 7, it would have stood as followeth:

Square 12418576 (3524 Root.

$$\begin{array}{r}
 9 \\
 \hline
 341 \\
 325 \\
 \hline
 1685 \\
 1404 \\
 \hline
 28176 \\
 28176 \\
 \hline
 00000
 \end{array}$$

Caution.

Caution.

If at any Time you look for the Remainder upon your Rods, and you cannot find it there, you must then place a Cypher between the Lines, and proceed to the next Figure, as by trying this other Example, which I have inserted for Practice, will appear.

Another Example added for Practice.

$$\begin{array}{r}
 90 \\
 54895 \\
 67 \\
 21 \\
 2 \dots \dots \dots \\
 117716237694 \\
 \hline
 843098 \\
 \hline
 9 \\
 256 \\
 2049 \\
 617481 \\
 5489504:
 \end{array}$$

N

C H A P.

C H A P. X.

*Concerning the Extraction of the
Cube-Root.*

THERE is somewhat more Difficulty in Extracting of the Cube, than of the Square Root. Wherefore (before I come to an Example) I will deliver the Manner of the Operation, together with such Cautions as are to be observed in the Performance thereof; all which immediately follow in this

GENERAL RULE.

Write down the Number whose Cube Root you are to extract, and under the first Figure towards the right Hand make a Prick or Point, and so under every third Figure towards the left Hand, till you come to the end of your Number. Under these Pricks draw two parallel Lines, (as you did in Extracting the Square Root) between which Lines you are to place the Figures of your Root as you find

find them: — Then beginning at the Figure (or Figures) of the left Hand Prick, and going forward towards the right Hand, extract (by Help of the Rod for Extracting the Cube Root) their Root, or, if the true Number be not on the Plate, then the nearest less, and, placing this Root (which never exceeds one Figure) between the Lines, and under its Point, take its Cube from the uppermost Figure, which stands before (or leftwards of) the first Point, and note the Remainder above.

Secondly, Keep the Triple of this Root found, in the Head or Top of the Rods, and triple the Square of the same Root, and set this Triple on the Head of the Rods, and apply it leftwards of the Cubick Rod, and the reserved Rod (or Rods) rightwards, the Cubick Rod being in the midst between them; and out of the left Hand Rods, and the Cubick Rod together, pick or find out the Multiple, (or next less Number than the Figures preceding the second Point) which write apart in a Paper, and note its Quotum over its utmost right Hand Figure, and write the Square of that Quotum leftwards from the Quotum itself, even in that Order as you find them in your Cubick Rod; and

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under every several Figure of this Square, write their Multiples found rightwards, even such as the Figures themselves do shew; so that every Multiple may end under its Figure or Quotum: Then add together these Multiples cross-wise, and take their Sum from the Figures foregoing the second Point, and write the Remainder over them; but write the right Hand Quotum, before noted, under the second Point between the Lines, for the second Figure or Quotum of the Root: And so is performed the Operation of the second Point, which you must repeat through the several Points, even to the last.

But in the Practice by this Rule, you may sometimes be at a stand, wherefore to this **GENERAL RULE** (that there may be no Obstacle) I will add these two **CAUTIONS**.

CAUTION I.

But in all Operations and Points it must be observed, That if no Multiple (no not the least of all) found in the left Rods, and the Plate, can be subtracted from the foregoing Remains; then a Cypher [0] must be put under that Point for
the

*the Quotum, the Remains being untouch-
ed, and abiding as before.*

CAUTION II.

*And if the aforesaid Sum, to be taken
away, cannot be taken from the Figures
going before its Point, the smaller Multi-
ples must be added, which the next upper
Quotums in the Cubick Rod do shew in
the Rods, whose Sum may be taken away
therefrom.*

Example of the Cubick Extraction.

Let 22022635627 be a Number gi-
ven, whose Cube Root you desire: Set
down your Number, and point it, (be-
ginning at 7, the last Figure towards
the right Hand, and so under every
third Figure) and draw two parallel
Lines under it, and it will stand in this
Manner;

22022635627

Look in your Rod, for the Extracting
the Cube Root, for the nearest Cube
Root of the Figures of your given
Number, standing before the first Point
towards your left Hand, namely, for
the nearest Cube Root of the Number

N 3

less

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less than 22, which you shall find to be 2, which set between the two Lines just under the first Point, and its Cube (which is 8) set under the Line, and substract it from the Figures above the Line, namely, from 22, and there will remain 14, which place orderly above, then will your Work stand thus, and the Work of your first Point finished;

14

22022635627

2

8

Secondly, For the finding of the Root belonging to the second Prick, triple the Quotum, or Figure which is under the first Prick, (namely 2) and it is 6; find therefore a Rod which hath 6 at the Head thereof, and lay that Rod by the Side of your Cubick Rod towards the right Hand, then triple the Square of 2 (which is 4) and it makes 12, which, found among the Rods, place by the Side of the Cubick Rod towards the left Hand.

Then from the Rods which lie on the left Hand of the Cubick Rod, and the Cubick

Cubick Rod itself, find the nearest lesser Number than the Figures standing before the second Prick, namely, less than 14022, and in the ninth Place you shall find 11529, which write by itself, as in the Margin, and over 9, the last Figure towards the right Hand (drawing first a Line between) set its Quotum, and by it its Square 81, in the same Order as you find them stand in your Cubick Rod.

$$\begin{array}{r}
 819 \\
 \hline
 11529 \\
 6 \\
 48 \\
 \hline
 16389
 \end{array}$$

Then write under 1, its Multiple, which is shewed rightwards against 1 in the Cubick Rod, and is the single Figure 6, and under 8 write the Multiple, that it shews rightward against 8 in the Cubick Rod, which is 48, and these three Multiples so written cross-wise below the Line, and added together (as in the Margin) do produce 16389, which, because they cannot be taken from the upper Figures standing before the second Point, namely, from 14022, the Number 9 (before taken) is to be rejected, as being too great, and instead of 819 (by the second Caution) the next higher Notes in the Plate are to be taken, which are 648, and the

Mul-

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Multiples that these do shew, namely, the Octuple among the left Rods, which is 10112, and the Quadruple among the right Rods, which is 24, and the Sextuple

among the right Rods, which is 36, being added cross-wise (as in the Margin) do produce 13952, which subtracted from 14022 (the Figures standing before the second Prick) there remains 70 for

the Remainder of the second Prick, and let there be taken for the Quotum of the second Prick, the right-most of the chosen Figures 648, which is 8, which place under the second Point between the Lines ; so is the second Figure of your Root found, and your Work will stand thus ;

$$\begin{array}{r}
 70 \\
 14 \\
 22022635627 \\
 \cdot \quad \cdot \quad \cdot \quad \cdot \\
 \hline
 2 \quad 8 \\
 \hline
 8 \\
 13952
 \end{array}$$

Thirdly,

Thirdly, Put the Triple of the precedent Quotums (*viz.* 28 between the Lines) which is 48, being taken out of the Rods, and put them on the right Side of the Cubick Rod, and get the Triple of the Square of the same 28, which may be found to be 2352, which

28	take out of the Rods, and
28	place on the left Side of the
	Cubick Rod; and of the Mul-
224	tiples on the left Hand Rods,
56	and the simple single Figures
	upon the Cubick Rod (the
784	least of which being 235201)
3	there is none so little that
2328	

may be subtracted from the Figures belonging to the third Point, namely, from 70635: Therefore (by the first Caution) the Remains abiding, or continuing as they are, you must put a Cypher under the third Point, for the third Quotum belonging to the third Point: And thus the Operation of the third Point is accomplished, and the Work will stand as followeth;

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$$\begin{array}{r}
 70 \\
 14 \\
 22022635627 \\
 \hline
 2 \quad 8 \quad 0 \\
 \hline
 8 \\
 13952
 \end{array}$$

Fourthly, Set the Triple of the foregoing Quotums (*viz.* 280) which is 840 on the right Hand, and the Triple of the Square of the same 280, which is 225200 on the left Hand, and the Cubick Rod between them; then, out of the leftmost Multiples, choose that which is next less than the Figures belonging to the fourth Point, namely, 70635627, which is this 70560027, which stands against 3 on the Tabulat; wherefore write this Number 70560027 upon Paper, in the Margin, with a Line over it, and set over the Line the

the Quotient 3, over its right-most Figure, and the Square of the said Quotum 3, which is 9,

$$\begin{array}{r} 93 \\ 70560027 \\ \underline{7560} \\ 70635727 \end{array}$$

leftward thereof, and the Noncuple found in the right Hand Rods, which is 7560, write under 9; let these two Multiples be added as in the Margin, and the Sum will be 70635617, which subtracted from the Figures foregoing the fourth Prick, and there will nothing remain; therefore let the right-most of the Figures of 93, viz. 3, be placed under the fourth and last Point, for the fourth and last Quotum of the Root, and so the whole and perfect Cubick Root of the given Number 22022635627, is 2803, and, since nothing remained, it is a perfect Cubick Number. The like is to be done in other Numbers, but I shall forbear to give you any more Examples, there falling out in this all the Variety that at any Time may happen for the *General Rule*; and the two *Cautions* before premised are here made applicable to Practice; wherefore to this Treatise for the present I will put

F I N I S.

ERRATA:

Page 12, Line 25, for 3 *Degr.* read 31 d. 46 m.

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